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*Teacher's Manual for*

# HOW AND WHY CLUB

The HOW AND WHY ScienceBooks

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A TEACHER'S MANUAL
AND SCIENCE HANDBOOK
*to accompany*

# THE HOW AND WHY CLUB

## BOOK IV

*of the*

HOW AND WHY SCIENCE SERIES

*including also*

A KEY TO THE COMPANION BOOK

*Prepared by*
HELEN DOLMAN MacCRACKEN

CONTENTS



THE L. W. SINGER COMPANY, INC.
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THE HOW AND WHY SCIENCE BOOKS

WE SEE (PRE-PRIMER)
SUNSHINE AND RAIN (PRIMER)
THROUGH THE YEAR (GRADE 1)
WINTER COMES AND GOES (GRADE 2)
THE SEASONS PASS (GRADE 3)
THE HOW AND WHY CLUB (GRADE 4)
HOW AND WHY EXPERIMENTS (GRADE 5)
HOW AND WHY DISCOVERIES (GRADE 6)
HOW AND WHY EXPLORATIONS (GRADE 7)
HOW AND WHY CONCLUSIONS (GRADE 8)

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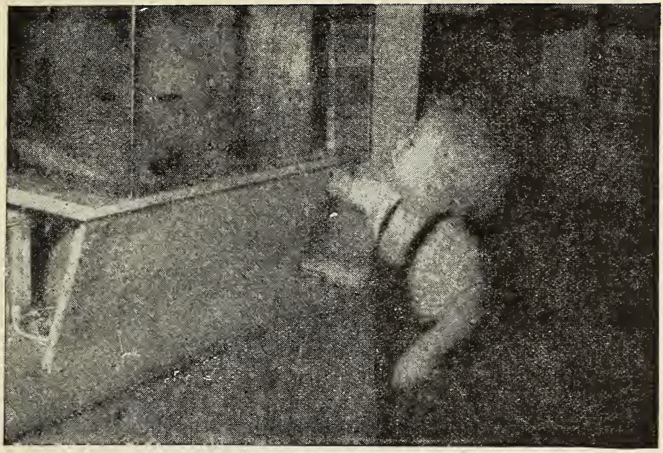

*"All knowledge begins in wonder."*

# *ELEMENTARY SCIENCE*

## THE PHILOSOPHY OF SCIENCE TEACHING

Someone has said, "All knowledge begins in wonder." A child entering school for the first time brings with him spontaneous enthusiasm and interest in the world about him which manifest themselves in an eagerness to relate his experiences. He is full of questions about the caterpillars, frogs, turtles, and other live things that he finds as he plays. He is curious about the weather, the heavenly bodies, and other physical phenomena of his environment. He asks how and why the mechanical devices of his everyday experiences work.

Too often this natural curiosity of the little child is lost instead of being developed during the first few years of school life, because teachers and parents feel their inadequacy to meet the situation. The knowledge required to answer all these questions is so great as to discourage the average adult. When children are curious, they have no respect for the lines of subject matter. One question may fall in the field of biology; the next in physics or chemistry. To



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answer all questions completely might well require more knowledge than even a specialist would possess.

However, to teach science to children it is not necessary to be able to answer all their questions. The alert teacher with abundant enthusiasm and curiosity can help them find the answers to many of their own questions. Nowhere will her efforts bring more satisfying results than in the teaching of science.

The philosophy of science teaching differs very little from that of any other subject. It is the subject matter which makes the handling of it more difficult, because teachers are not generally trained for science teaching. The teacher must take into account those things in the child's experience which lie in the field of science. There are many experiences common to children everywhere that may become the foundations of our science work. From these common paths teachers may diverge with the interests of individuals and the groups, and adapt the teaching to the local community or section of the country.

We live in a world that is changing so rapidly that what is grist for the science mill today may become a waste product tomorrow. One day a Byrd explores Antarctica; a Beebe explores the depths of the ocean; or a Piccard penetrates the stratosphere. At such times even first-graders may discuss the stratosphere but to put the stratosphere into a first-grade book, in the light of our present knowledge, would be questionable.

Again, the children we teach are affected by varied environments. Those of the western plains have a whole set of animal concepts not possessed by children of the Atlantic coast. Children in a mining town, children from the country, children from a metropolis—all have experiences which give them different ideas. But through all these experiences the teachers may teach the same scientific principles. For example, hibernation of animals may be taught to a western child by a study of snakes; to a child in the lake region by a study of frogs; to a child somewhere else by the study of clams, crayfish, or some insect.

In science, the teacher needs to remember individual differences. Some children respond more freely to experiences with plants, some to animals, some to physical science. By encouraging children to express themselves freely in the classroom, and to experi-

ment for themselves with the materials found in the science room, the teacher can discover these differences and make effective uses of them.

Above all, to be a successful teacher of science, one must be enthusiastic about the subject, enjoy working with children, and understand the way they think. She must be scientific in her own attitudes and be able to use the problem-solving method of teaching. She does not have to be a specialist in science nor be afraid that she won't know all the answers. She probably won't be able to answer all the questions which the children ask, but even if she can, to do so would spoil the fun for the children. She need not hesitate to say, "I don't know," providing she continues, "but we'll find out together." Science teaching can be a shared experience of teacher and children that has great possibilities for both.

## OBJECTIVES FOR TEACHING SCIENCE TO CHILDREN

Science for the grades should not be regarded as a mere accumulation of facts but as a series of experiences with the science materials that are a part of every child's daily life. These experiences stimulate the curiosity of children and if used properly should lead to behavior changes in the children. To accomplish desirable outcomes the teacher should understand the reasons why anyone studies science. These reasons may be called objectives. Scientists differ in the way they state these major objectives, but they agree on their content. Briefly stated, these objectives of elementary science are:

1. To develop an intelligent appreciation of the natural and physical world.
2. To develop scientific attitudes.
3. To help children acquire the scientific method of problem solving.
4. To help children acquire useful science concepts.

By an intelligent interest and appreciation of the world in which he lives, a child is made aware of beauty that goes deeper than

the mere appeal to the senses. Appreciation should grow as knowledge is gained. The person who gets a satisfaction from the color and form of a beautiful butterfly should enjoy it more after seeing its transformation from pupa to adult. The child who, looking intently at a butterfly's chrysalis, exclaimed, "Oh, I can see the wings through the chrysalis skin!" was experiencing appreciation. Children should get a thrill out of their science experiences which will make their lives richer and more enjoyable.

Appreciation should lead to the conservation of wild life. The biological principles of the struggle for existence and survival of the fittest tend toward a balance in nature, unless man upsets the balance. Through experiences with material such as that used in "Insects in the Garden," "Birds in the Orchard," and "Life in the Pond," children may be led to see the relationships of plants and animals. They learn which ones are harmful, and what to do about them, as well as which ones are helpful to man.

The second objective, that concerning scientific attitudes, should run through all science teaching. The child who develops scientific attitudes:

(*a*) Will have a conviction of basic cause-and-effect relationships which will make it impossible for him to believe in superstition or unexplained mysteries.

(*b*) Will have a sensitive curiosity which will lead to making accurate observations, collecting data, and searching for adequate explanations.

(*c*) Will have the habit of delayed response, preventing him from making snap judgments or jumping to conclusions.

(*d*) Will weigh evidence carefully to find out if it is sound, pertinent, and adequate.

(*e*) Will have respect for another's point of view, and be willing to change his point of view in the face of new evidence.

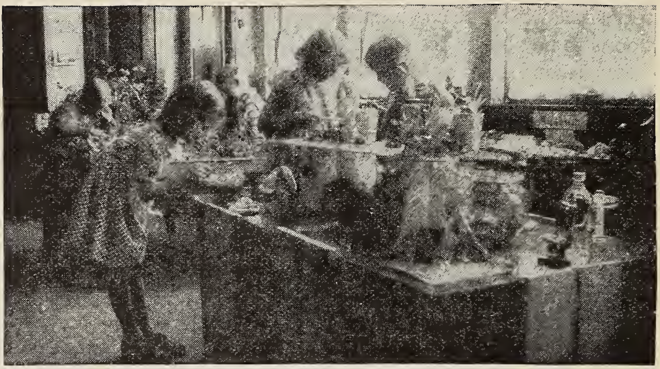
These may sound formidable to the teacher who has had little training in science. She may recognize them as desirable outcomes, yet not have the slightest idea of how to go about teaching them. She need not be frightened, however, because the techniques by which she helps children develop scientific attitudes are

very similar to those she uses to develop social attitudes. The first step is to be able to recognize a *lack* of the attitudes.

For example, a child who says, "My grandmother says the ground hog saw his shadow and he can tell about the weather," has not developed the attitude of looking for a cause. The teacher could help him develop the attitude by saying, "That is interesting. I wonder what makes your grandmother think that," or, "I wonder how the ground hog (woodchuck) knows." The child may answer, "If he sees his shadow on ground-hog day, we'll have six weeks of bad weather." Then the teacher may say, "That may be true, but what do the rest of you think about it?" After a brief discussion she may say, "All of you are just giving ideas. Is that the way scientists (or people who study woodchucks) would settle a question?" The children may suggest watching for woodchucks or discussing the weather on February 2—will the woodchuck see his shadow or not? They may watch the weather for six weeks, recording it and comparing the actual weather with the woodchuck's "prediction." Some child may be bright enough to remark, "It may be cloudy in the fields south of town and the sun may be shining on the north side. The north side couldn't have six weeks of bad weather while the south side is having good weather." The grandmother (who would have resented it had the teacher said, "That idea is not true, Tom,") may become interested in a long-time experiment; but, whether or not there is hope for grandmother, Tom's plastic mind has been affected by six weeks of observing and checking.

Later when Dick insists that horsehairs turn into snakes, Tom will be eager to bring rain water and a horsehair to find out if Dick is right. Bit by bit, these experiences will straighten out Tom's thinking until one day he will say, "I don't believe in superstitions. One day when we were out driving, a black cat ran across the road. Later we had engine trouble, but the trouble was caused because a part had worn out."

Not only is this attitude taught by correcting existing superstitions and misconceptions, but it impels children to look for the causes of all natural phenomena. Numerous opportunities arise every day to develop it. For example, in trying to solve the problem of why food spoils, the teacher may ask, "Where does your



*Independent investigations.*

mother put food that she wants to keep?" Through discussion someone may say, "Temperature will affect food. When food gets hot, it spoils." In problem solving there are many opportunities to teach scientific attitudes.

The ability to interpret natural phenomena correctly does away with unreasoning fears. The child who understands the cause of thunder, and has demonstrated the sound in a small way by clapping his hands, is not so likely to be afraid of it. Knowing that animals are not likely to sting or bite except in self-defense, he is less susceptible to the fear carried by many people into adult life. The person who has studied about meteors and northern lights doesn't assign mysterious reasons or results to these natural phenomena. The child's understanding of the cause and prevention of disease helps keep him from carelessly exposing himself and others, as in the case of colds. He learns that everything has a cause; that disasters don't just happen, nor, as was once believed, are they visited upon us as punishment.

Curiosity concerning their environment is natural to children, though some have more of it than others. But sensitive curiosity may have to be taught. Children ask many questions to which they really don't expect an answer, nor care for one. Sensitive

curiosity is demonstrated by a perseverance on the part of the child in asking a question, or in independent investigation on his own initiative. Children should be given opportunities to tell of things they observe that stimulate their interest and curiosity. If learning is dependent upon desire to know, then curiosity is a valuable attitude to develop. Some children have it to such a degree that no amount of squelching on the part of adults will stop their investigations. They learn in spite of their teachers. Other timid ones stop asking when they get no satisfactory explanation. The child who persisted in saying, "I *want* to *know* what makes the bubbles in cake," after the teacher had told her it was too hard for her to understand, had unquenchable curiosity.

The ability to make accurate observations and the ability to collect data are outcomes of the attitude of sensitive curiosity. Some techniques which help in the teaching of this attitude are:

(*a*) Making use of the children's suggestions of ways to collect data—for example, when Mary wonders what will happen if a prism is held in a cloud of dust while a sunbeam is striking it, let Mary try the demonstration, using chalk dust.

(*b*) Insisting upon accurate descriptions when a child reports having seen something—for example, when a boy describing an insect the size of a gnat, tells of a yellow stripe around its body, the teacher may say, "Just a minute. How could you see the yellow stripe on an insect no larger than a gnat? Tell just what you saw. If you didn't see the color, don't tell about it."

(*c*) Setting an example of collecting data by asking questions about many points which the children have not mentioned in their descriptions.

(*d*) Insisting upon experimentation or demonstration being directed to the purpose of gaining adequate explanations. Children are likely to become more interested in the working of the apparatus than in the answer to their original question. Then the teacher may say, "Why are we doing this experiment? Is it helping to answer the question? It is an experiment only as long as you are learning. After that it is play."

The attitude of delayed response is developed by insisting on the children's not "jumping to conclusions." The child who says, "I saw a bird. I *think* it was a woodpecker because it was tapping on a tree," or "I *think* the fish died because we didn't put any green stuff in the aquarium like we do at home," or "I'm *not sure,* but I don't think the air does all of the work of holding the plane up," has developed the attitude. The child who says, "I *know* that was a fallen star. There are a lot of them around here," hasn't developed the attitude.

To help develop the attitude of delayed response, the teacher must be on the alert with answers such as:

"We must be careful and not think we have found out something when we really haven't."

"Do you think you should say they are fallen stars? Has anyone proved it?"

"Let's save that question and answer it later. Then we will find out more about it to help us be sure." (And don't forget to do it!)

Having developed the attitudes of basic cause and effect, sensitive curiosity, and delayed response, children are ready for weighing evidence. Children are usually eager to express their ideas without thought as to whether they are pertinent or sound. When the teacher is just starting her science program, she may encourage expression to get things under way. After the ice is broken and the children are no longer inhibited or shy, the teacher has to curb their enthusiasm and direct their thinking.

To do this without breaking their line of reasoning takes skill. The teacher must not be discouraged if her first attempts at developing attitudes result in confusion. She may have to go back to the beginning of the lesson and start over. When this happens, the teacher should take the children into her confidence by smiling and saying, "I guess I got us off on the wrong track. Let's see where we were," or "We're all mixed up. You'll have to help me. What were we trying to find out?" The children will respond to this.

Some ways to help develop this attitude of weighing evidence are to give suggestions like:

"Let's remember not to take too much time with details that don't really have anything to do with our problem."

"Does your question have anything to do with electricity? Have you thought it through?"

"Do you think that we have enough information to answer the question?"

"Should we decide before we know what a scientist has to say about that?"

"Let's keep our minds on one track."

By consulting an authority, the teacher should check often on the accuracy and soundness of the experiments being done. The children should check with their science texts. They should never draw conclusions from one experiment.

A child who has developed this attitude will say things like this: "I think the tooth comes from the upper jaw by the way it curves. If you'll look at a dog's teeth, you'll notice that the upper teeth curve down over the lower teeth. It's hard to tell whether it's the upper tooth of a big bear or the lower tooth of a small bear," or "We haven't read it carefully enough. He forgot to use a marker so I don't think it would be right."

Willingness to change one's opinion in the face of new evidence is the most advanced attitude of all. The person who has it is tolerant, without prejudice and bigotry. If all the children in the world could really be taught this attitude so that it would function, wars would cease. Science has no monopoly on this attitude, but it offers an excellent opportunity for its natural development. In social studies areas, emotions are more likely to be involved. In solving science problems, children can be more objective. The teacher may say:

"There is a sentence on that page that isn't exactly scientific. Scientists have found out more about it since the book was published."

"When one has the floor, let's remember that others want to talk also, and not take too much time."

"Don't laugh. I'm not surprised that he's mixed up. Grown folks get mixed up, too."

"Do we laugh at people who have ideas?"

"Let John have his chance. Let's listen to what he has to say."
"I think he has an idea, but it just isn't very clear."
"Evidently there are three people who do not agree."
"Jane listened to you; now it is her turn."

Allow every child an opportunity to tell one thing he has observed or learned from an experiment. Give careful consideration to every child's serious question or attempt to explain something. If the teacher respects children as individuals, respects the importance of their problems, and is willing to change her own mind when she sees that she is wrong, it will help in teaching this attitude.

The child who has this attitude will say, "I don't quite agree with her because I think there is a change in the temperature of the land," or "I thought the candle wick burned, but now I know that it is the gas that burns."

Children often have pretty definite ideas about their experiences and are not willing to change those ideas. For example, many people use widely advertised products in their homes without investigating their true value. One science group made a study of some of these products and discovered that the advertising was misleading. The children in the group were learning to evaluate and test statements in the light of evidence.

Willingness to change opinion, to search for the whole truth, and to base judgment on fact are all closely related and may be developed together. They may all result from a comparison of experimental data or accurate observations.

A child may have formed some incorrect idea that he has heard or read in a book. For example, a child insisted that "beavers carry mud on their tails" because he had read it in a children's storybook. The other children challenged his statement. The teacher asked how they could know whether or not the statement was correct. The children said to ask a scientist or look it up in several books written by scientists who had studied beavers. When this was done, the child who had made the statement saw that his idea was wrong. He also realized that he could not believe everything he read.

## SOME GENERAL TECHNIQUES FOR TEACHING SCIENCE

Although the information and skills needed by teachers for teaching problem solving to children are presented at considerable length on pages 11–18 in each of the Primary Manuals for THE HOW AND WHY SCIENCE SERIES, an examination of an actual lesson may be of value here.

One of the most difficult techniques for a teacher to master is that of motivation or "problem setting." The ideal way for problems to arise is through spontaneous questions from the children, but this seldom happens until children are well into the science program. Often the teacher must arouse interest and bring to the surface the questions which may be in a child's mind. The skillful teacher can do this in such a natural way that it is not superimposing a topic for study but guiding the thinking of the children. The secret of gaining whole-hearted cooperation in the solution of a problem often lies in this technique. An example of a motivation and exploration period followed by the techniques used in solving a fourth-grade problem will illustrate this.

These fourth-grade children had been studying magnets and were ready for some work with electricity. The teacher asked the children to think of ways in which electricity is important to them. She asked, "How many things that use electricity do you have in your homes?" As the children responded, the list was written on the blackboard. The list stimulated some discussion. Sammy said, "When you rub your feet on the rug you get electricity." Some of the children said that they didn't think it was electricity that he was talking about. Jane said, "You can't run anything with it." Had Jane not made this comment the teacher might have asked, "Can you run a sweeper with it, Sammy?"

Sammy defended his statement by saying that he sometimes got a shock and saw a blue spark. Several children had explanations for these happenings so at the peak of the discussion the teacher asked, "Are you being scientific? You are all giving your opinions but I wonder if that is the way a scientist would settle a question." Since by this time all of the class was interested and ready to state problems, these were listed and written on the board. Some of the questions were:

1. What makes a shock and a spark when you walk across a rug and touch something like a doorknob?
2. Why does the radio go off when you drive under a bridge?
3. What causes static on the radio?
4. What makes telephone wires hum?
5. How does water make electricity?
6. How does electricity make a light go on and off?

The class read the problems and decided to start with:

PROBLEM: What causes the shock when you walk across a rug and touch something?

ANALYSIS:

The teacher directed the analysis of the problem with questions like: "Do you always get a shock when you walk across the floor?" Several children were allowed to demonstrate. Nothing happened. Reasons were suggested, such as: there was no rug on the floor; they didn't scrape their feet. Bob said that he had walked across a bare floor and "made" electricity and that he could do it again. He was asked to try it and was puzzled when he got no results. Since it was a rainy day the teacher suspected that the moisture in the air was responsible, but she merely said, "It is time for us to end our science lesson today. Why don't all of you try the experiment at home tonight on a rug?"

The next day the rain had ceased and the air was crisp and cool. The children had repeated the experiment at home and were ready to report results. Some had managed to get a slight shock, some had not. However, they were ready to give some possible solutions to the problem.

POSSIBLE SOLUTIONS:

Perhaps the temperature causes the shock when you rub your feet very hard on the rug.

Perhaps you and the metal you touch act as two poles which have an attraction for each other. (This idea grew out of their experiences with magnets.)

Perhaps the shock is caused by friction.

As each of these possible answers to the problem was given, it

was discussed to make sure that the child wasn't repeating words he had heard, without understanding them. For example, the teacher asked, "Do you know what friction means?" The child who had used the word said, "Oh yes. It means something strange and wonderful—you know, stranger than friction."

Obviously the word needed clarification. Other answers were: "I think friction is a kind of electricity." "I think friction is like a spark or shock." Finally a child said, "I looked up friction in the dictionary and it said 'rubbing two things together.' "

These answers are given to impress the importance of word meanings. Teachers know that it is essential for children to connect the correct concept with a printed symbol when reading. In a science class, unless all members have the same concept of a word used in discussion, accurate conclusions cannot be drawn. The illustration of the child who confused friction with fiction shows how he could give a seemingly correct answer and still have an incorrect idea.

Having given possible solutions, the children discussed ways of testing them. They thought of experimenting and reading. At this point the teacher remarked that she knew of some experiments in THE HOW AND WHY CLUB which might help.

SOLUTION:

The children read page 315 and the first three paragraphs of page 316 of THE HOW AND WHY CLUB. The experiment suggested others to them and they did the following:

1. Rubbed a pen on woolen clothing and held it near bits of paper.
2. Repeated the experiment with various objects, such as combs, pencils, and rulers.
3. Rubbed pieces of paper on their desks.
4. The teacher suggested the following:

A piece of glass was placed between two books so that the center of the glass was about one half inch from the table. Bits of paper were scattered on the table below the glass. The top surface of the glass was rubbed briskly but lightly with a piece of silk. (If it is rubbed too hard, the experiment may not work.)

Results:

Some exclaimed, "The paper sticks to the desk!"

Tom said, "I rubbed two pieces of paper together and they stuck together. When I pulled them apart they crackled."

Ruth said, "I'm not sure, but maybe when you rub something fast and hard it gets hot. Is that friction?"

Jack asked, "When you rub a balloon on the floor and stick it against the wall, what makes it stay?"

These illustrate the thinking done by children when they are allowed to experiment freely and to express their reactions.

During this period the teacher listened, counterquestioned, and helped children who were having difficulties. When she saw that the activity had accomplished its purpose, she said, "May I have your attention, please?" Then she asked, "What did you find out?" Every child who had something to say was allowed to report on his results before the teacher asked for a summary by saying, "Can someone put everything you have said into a few good sentences?"

These were given and written on the blackboard:

What Happened:

When we rubbed a pen or comb on woolen cloth, it picked up pieces of paper.

When a pencil was rubbed on wool, it did not pick up the paper.

When a piece of paper was rubbed against a desk or blackboard, the paper crackled when it was pulled away.

When a piece of glass was rubbed with silk, the pieces of paper under the glass jumped around. Some of them stuck to the glass.

The teacher asked what they now thought about their possible answers. The class decided that the last one was best. The teacher then suggested that they re-read together pages 315 and 316 of The How and Why Club. (Reading orally clears up any mistaken ideas some children may have received as they read silently.)

Following the reading, the discussion brought out the following conclusions:

Mary said, "I think that friction when you walk across the rug causes you to unconsciously pick up electricity."

Shirley said, "I'm pretty sure it is friction because it said so in the book."

Other children stated similar ideas. These were written in their notebooks:

WHAT WE LEARNED:

> When you rub your feet on a rug, electricity is generated by friction. The electricity travels through your body and attracts electricity from whatever you touch. The electricity gives you a little shock.

Had this been an older group of children, each one would have been allowed to write the conclusion in his own words but since these children were just learning to write the steps in problem solving, they gave their ideas orally, then copied the group answer from the blackboard.

A discussion followed of why there is more evidence of static electricity on a cold dry day than on a warm damp one. This is due to the fact that water is an excellent conductor of electricity and the droplets in the air conduct it away as fast as it is generated.

Teachers may contend that this procedure is too time consuming, that the same goal may be accomplished more quickly by reading the text. The author believes that the increased growth in a child's ability to think for himself and the added interest repay the extra time. Over a period of years time is actually saved, since concepts once gained are not forgotten.

The author has taught the same children science from the first grade through the sixth and been amazed to find how much knowledge they accumulated in that time. Very seldom did a concept have to be re-taught. When it was reviewed, though some children seemed not to remember, the others did and it was recalled quickly by the whole group. When no one remembered, the teacher knew that the children had not developed the understanding of the concept in the first place, perhaps because it was too difficult for the age level or because it was poorly presented. More important, through the methods used, the children were independent in their thinking and enthusiastic in their attitudes toward science material.

The following lessons illustrate other types of activities used in solving science problems.

### Problem Solving Lesson—Grade 5

*Using observation and experimentation*

The children knew that a young porcupine had been brought to the science room before they came to class, so all eyes were turned toward the cage and there was a buzz of private discussions and occasional distinguishable tones of disagreement as the children found their places.

Teacher: "What is in the cage?"

Child: "A porcupine."

For a few minutes the children told of experiences they or their friends had had with porcupines. Conflicting points of view brought up the question of how the quills were released from the porcupine's body.

I Problem: How do quills get out of the porcupine?

II Analysis:

Question: I have two quills from this porcupine. How do you suppose they got out of his body?

Answers:

1. Maybe the quills were loose and when you got real close he raised them up and they stuck fast to something.
2. Maybe he shot them out.

III Hypotheses:

1. Perhaps the quills stick fast to anything they touch.
2. Perhaps the porcupine shoots out his quills.

The first two possible solutions were suggested and tested. Neither solved the problem, so teacher and pupils discussed the scientific method to be used when hypotheses first suggested fail to solve a problem.

They decided some additional possible answers must be suggested. The teacher helped the children in their thinking by asking them to think of experiences dogs have with porcupines. From an account of a dog's chasing a porcupine and snapping at it the children formed these hypotheses:

3. Maybe it takes pressure for the quills to stick fast.
4. Perhaps the porcupine has to be frightened before the quills will stick fast.

IV SOLUTION:

A. Gathering Data:

Materials used: Shingle with strip of cloth wrapped around it near one end, rubber gloves, stick for prod.

Teacher: Have you any suggestions as to how we may solve the problem?

Children: 1. Read.
2. Ask someone who knows.
3. Experiment (try something).

Experiments:

1. A child touched the porcupine with a stick.
2. The teacher touched the porcupine with rubber gloves on her hands.
3. The children watched the porcupine when he was frightened by noise and a prod.
4. A boy pressed the stick wrapped with cloth against the porcupine's back.

B. Results:

1–2. The quills did not stick to the board or the glove.
3. The porcupine did not shoot any quills.
4. Quills stuck to the stick wrapped with cloth.

V CONCLUSION:

Quills stick fast to a soft object if pressure is used.

The teacher wrote each step of the problem solving on the blackboard as it was given under the headings: Problem, Suggested Answers, What We Did, What Happened, and Conclusion. As a number of the children were not familiar with the problem-solving method, the teacher asked that each copy the material from the board for their own notebooks.

To confirm their conclusions, the children read page 85 of HOW AND WHY EXPERIMENTS.

I Problem: Why are sandstones different colors?

II Analysis:

Teacher's question: "What colors are sandstones?"
Children's answer: "Sandstones are mostly white and red, but I don't know why."

III Hypotheses:

1. Perhaps the sun has something to do with the colors.
2. Perhaps the sand that the rock was made of was different colors.
3. Perhaps the color was caused by what sticks it together.

IV Solution:

A. First Experiment
  1. Gathering data
    *a.* The children put different kinds of soil and crushed rock into jars of water, shook them well, and placed them on the window sill to settle.
      (1) Jimmy ground red sandstone and put it into his jar.
      (2) Gertrude used white sandstone.
    *b.* The next day the children brought different colored sandstones which they had crushed at home.
  2. Results
    *a.* The next day the children looked at the jars of crushed rock and noticed several things about them.
      (1) The material appeared in layers.
        (*a*) The coarser material was on the bottom.
        (*b*) The finer, sticky material was on top.
        (*c*) There was loose material on top of the water.
      (2) The material seemed to be different colors in some places. Each child showed his own experiment to the class and pointed out what he noticed about it. The class discussed why sandstone might be different colors.

B. Second Activity

1. Gathering data

   *a.* The next day Walter brought a rock which his grandfather said contained iron. The class discussed possible reasons why the rock might contain iron.

2. Results

   *a.* Walter brought out his rock that had been standing in water and the class looked at it and discussed the change.

   (1) Some of the rock had come off and made orange-colored sediment on the bottom of the pan.

   (2) The question, "What is rust?" arose. Many of the children gave examples of how iron had been left out in the rain and had rusted, or of different implements that had rusted.

   (3) The teacher then asked, "Does anyone see any connection between the color of rocks and rust?" One child answered, "Sandstone has some iron in it and it rusts. That's what makes it colored."

V CONCLUSION:

A. The cement sticking the sandstone together makes it colored.

1. The cement part may have come from iron ore.
2. The cement may be made of clay which is found in different colors.
3. When we looked through the microscope the sandstone didn't have any color, therefore it must be the cement part that gives the color.

The children read pages 163 and 164 in HOW AND WHY DISCOVERIES to confirm their conclusions.

## Problem Solving Lesson

*Written by a fifth grade child*

Problem: What makes the sky blue?

Possible Answers:

The sun hitting the moisture in the air may make the sky blue.
The sun shining on the dust in the air may make the sky blue.
Perhaps there is so much air that when we look through it the sky looks blue.
Perhaps it is because the sky is so far away.

What We Did:

Gilbert took a paper and put it in a sunbeam. He followed the beam with the paper. He put chalk dust in the sunbeam.
We put a prism in a sunbeam.

What Happened:

We could see the sunbeam shining on the paper.
We could see the sunbeam reflected on the dust.
The sunbeam going through the prism split into colors.

What We Learned:

The dust in the air acts as little prisms and splits the light into colors. Usually in the middle of the day only the blue gets to our eyes. The other colors shoot off into space. At different times different colors show, but most of the time it shows blue.

## HOW TO DO AN EXPERIMENT

The purpose of an experiment is to help in the solution of a problem. To be a real experiment it should originate with the persons who raise the question and be carried out by them. Since children do not often have the background to do this, they need help in directing their thinking. However, an activity suggested by the book or the teacher should help solve a problem. Too frequently teachers use a spectacular demonstration merely to get or keep the attention of the children and label it an experiment. While such an activity may be legitimately used once in a while it should not be called an experiment. It is a motivating activity.

If children have a problem to be solved they may learn the experimental technique no matter how simple the problem. Allow them to perform original experiments.

The first step in scientific method is the defining of the problem. The teacher should make sure that the children know what their problem is. It may be as simple as, "Why does a piece of wood float?"—a problem which may arise in any grade.

The next step is the analysis of the problem. The teacher must lead in this analysis by her questioning. She may ask, "How do you know that wood floats?" "What other things float?" "Can you think of ways we might find out why things float?" The children may suggest trying to float several things in water.

The next step is assembling of the materials needed for the experiment. In this case these are a tub of water, various articles such as a sponge, a rock, a cork, some wood, and a balloon. The children should suggest what they think is going to happen before they put the various articles into water. As they work the children will discover that the sponge floats until the holes are filled with water. As this happens air will escape into the water. The balloon will float unless the air is replaced with water. If the balloon is squeezed under water air bubbles will come to the surface as the balloon fills with water. The teacher must be sure that the children observe *carefully* and report *accurately* what happens. She must be sure to give them enough experiences upon which to base conclusions. By having several groups doing the same experiment the children will learn to check their results with those of others. The final check should be with an authority.

Teachers who are helping children to perform experiments will find that careful planning will eliminate confusion. In her plan the following steps will produce better results.

1. Write down the problem to be solved.
2. List the activities to be used in its solution.
3. Select the first experiment to be done.
4. List the materials needed.
5. Note any precautions to be used such as having a metal tray under a burner, or having soda or ammonia ready to counteract acid burns.

6. List the steps of the experiment in order of procedure.
7. Do the experiment yourself to familiarize yourself with the apparatus and procedure.
8. Jot down exactly how the children will be directed.

To avoid accidents the children should know and use safety measures. Before doing an experiment involving any danger, the children should discuss it and decide what to do in case there is an accident. A first aid kit should always be at hand and any accident used to teach first aid. The teacher should always try to anticipate anything which might happen and to teach the children how to avoid accidents.

Some of the common causes of accidents are careless handling of fire, acids, glassware, hot liquids, and poisonous chemicals. Even experienced teachers may become so interested in the experiment that they fail to notice such possible dangers as a child with long hair bending over a flame or a piece of paper placed too close to a fire. Acids should be handled carefully. The cork from an acid bottle should be held between the fingers with the acid-coated end away from the hand while the acid is being used and replaced in the bottle when one is through using it. Avoid touching clothing or skin with the end of the cork that has been in the bottle. Do not allow children to come too near liquids that are being heated because boiling liquids may sputter, splatter, and pop into their faces. Children should be taught to handle glassware with caution, to avoid being cut.

Warn children to keep fingers and other objects out of their mouths as this may be a means of carrying poisons to their mouths.

In some school systems there are rules against using fire or chemicals in the classroom. In these places teachers will have to substitute an electric plate for heat and use harmless substances such as vinegar and soda instead of hydrochloric acid and calcium carbonate. In most cases it is wiser to use simple chemicals anyway. Too often children have the idea that chemicals and chemical change are confined to the laboratory and do not realize that chemicals are common in their everyday lives.

*A science room.*

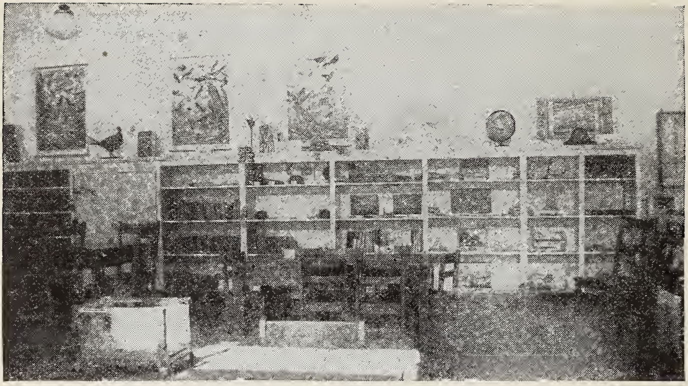
# *SCIENCE ACTIVITIES COMMON TO ALL GRADES*

## THE EQUIPMENT OF THE SCIENCE ROOM

Although it isn't absolutely necessary to have a separate science room for elementary science, it is often desirable. The room need not contain elaborate or expensive furniture and equipment. Many times it will be advisable to carry out the science activities in the children's own home rooms. Many schools have a science room where equipment may be stored and where live plants and animals may be kept.

The ideal room is located on a sunny side of the building with plenty of light for growing things. If the room is planned before the building is constructed a small conservatory may be provided in a large bay window with glass doors between it and the main room. Thus the temperature may be kept right for any living things with which the children may experiment.

An ordinary classroom may be adapted to the needs of a science class with very little expense. Water, gas, and electric outlets should be provided if possible. Shelves for books, specimens, and



*Shelves provide places for permanent collections.*

plants may be installed under windows and cabinets. A closet and built-in cabinets are needed for care of equipment. Bulletin boards and a blackboard are indispensable if classes are to be held in the room. Movable tables and chairs are preferable to desks. The tables should have a hard finish that is washable and not easily marred. Linoleum or newspapers may be used on ordinary tables to protect the tops.

Much of the equipment of the room may be made by the teacher and children with the help of the shop or manual arts teacher. Aquaria of varying sizes may be made or purchased at little expense. See the suggestions in another part of this manual for making and balancing aquaria.

Cages for small animals may be easily made of wire netting and crates. Insect cages and brooding cages are simple to construct.

Some source of heat is necessary such as gas, electricity, or an alcohol lamp. If you have gas, you will need a bunsen burner, a tripod, some wire screening, and a metal tray on which to work.

Jars and bottles of various sizes may be collected to use in place of the flasks, beakers, and test tubes shown in the texts. Pint salad dressing jars are a very useful size.

Coffee cans may be used for many experiments. Waxed paper cups are also useful pieces of equipment.

A compound microscope and a dozen reading glasses 2½″ or 3″ in diameter should be available.

A file to hold pictures and other bulletin board material is a great help. A substitute may be made of an orange crate.

Reference books, science texts, magazines, and pictures should be kept where the children can obtain them easily.

Since one of the habits we wish to have children gain is caring for equipment, dishpans, soap, and other materials should be provided for keeping things clean. Laboratory assistants may be appointed at intervals to help in preparing for and cleaning up after experiments and demonstrations.

A set of Audubon charts, a globe, a good map of the western hemisphere, and a sky chart all help in answering questions. A lantern and slides will also help.

Some dry cells, insulated copper wires, and magnets will be needed for any work with electricity or magnetism. Old switches, fuses, sockets, and other illustrative materials are easily obtained.

The combined ingenuity of the teacher and children should make it possible to collect the materials suggested in the activities or to find substitutes. While some schools have excellent equipment and well planned rooms in which science is taught, equally good teaching is being done in other schools without such advantages. Since science on the elementary level should grow out of the children's own experiences, the very materials that stimulate the questions will provide the answers. The really necessary factors are an alert, interested teacher, normal inquisitive children, and the environment. Below is a list of materials which may be collected from the environment.

*Glassware*

Salad dressing jars—straight sided and flask shaped.
Fruit jars.
Vinegar and pickle bottles.
Tall, straight bottles.
Different sized pieces of glass cut from broken windowpanes and windshield glass.
Tumblers.
Glass or china saucers.
Milk bottles.
Small-necked bottles.
Lamp chimneys.
Glass tubing.
Pipettes (medicine droppers).

### *Miscellaneous Equipment*

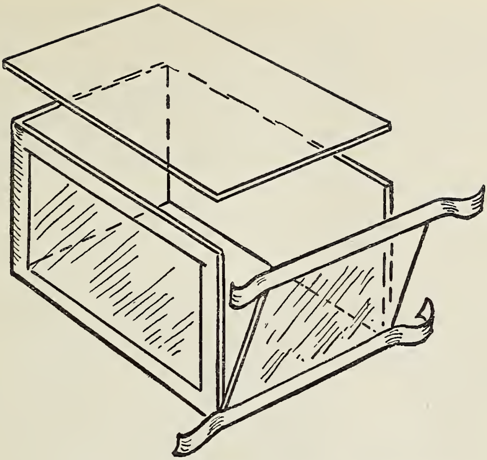
Flower pots.
Tin cups.
Spoons of different sizes.
Knives such as old butcher, paring, and case knives.
Pans that have been discarded to be used to carry snow, heat water, etc.
Pieces of wire screening, scraps of sheet metal, such as copper, zinc, and iron.
Toy balloons.
Cellophane.
Rubber bands.
Scissors.
Scraps of rubber sheeting.
Old balls of various sizes.
Cardboard boxes and cartons.
Chalk and other wooden boxes.
Wire—steel and copper.
Flashlight.
Dry cells.
Empty syrup and oil cans.
Corks of different sizes.
Dry cells.
Hard rubber comb, pen, or other object to use for static electricity.
Simple machines, such as egg beaters, can opener, and hammer.
Nails, tacks, screws, and bolts.

### *Supplies*

Matches and candles.
Starch, sugar, salt, soda.
Vinegar.
Ammonia.
Rubbing alcohol.
Lime for limewater.
Iodine.
Litmus paper, red and blue.
HCl.
Charcoal.

## HOW TO MAKE A TERRARIUM

A simple terrarium has so many uses that it is well to know how to make one. First, it is necessary to have a container. A glass jar of any kind will do, but one with straight sides is better than a round one. A glass box may be easily made from six pieces of window glass cut to the desired size. These may be fastened together with one-inch adhesive tape or black *passe partout* tape. Rub the tape until it sticks firmly to the glass. The lid may be fastened so that it is hinged, or merely laid across the top. All edges should be bound with tape to prevent cut fingers. A further precaution is to have the edges of the glass beveled at the time it is being cut.



*A terrarium made from glass and adhesive tape.*

A wooden base instead of a glass one may be used for the box. If wood is used, it should be so cut that at least one inch will project from around the glass at the bottom. The board may be treated with melted paraffin to make it resistant to water. A half-inch furrow should be sawed in the wooden base, the dimensions of the glass, and made wide enough to take the glass. The glass sides can be more firmly secured in the furrow by means of aquarium cement or putty. Adhesive tape may be put around the top to make smooth edges.

Having a container, start making the terrarium by putting a layer of gravel in the bottom, to provide drainage. Small pieces of charcoal will help keep it sweet. On top of the gravel put soil of the kind found where the plants grow which are to be used in the terrarium. For example, moss and ferns come from the woods. Use woods soil, or leaf mold, for a woods terrarium. Use garden loam for a garden terrarium. Use sand for a desert terrarium.

In the soil plant the moss, ferns, or other plants you wish to use. If you are going to put plant-eating animals into the terrarium, some of these food plants should be planted. For example, if

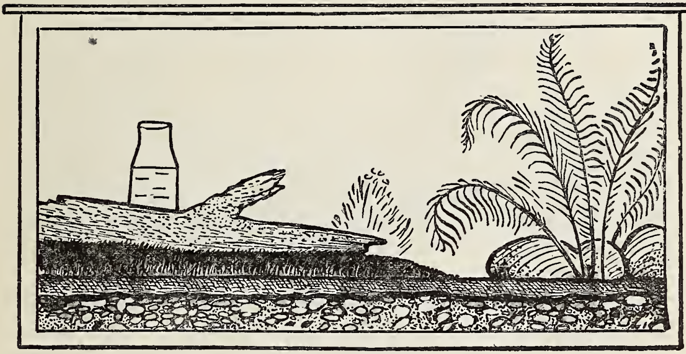
*Making a terrarium for a garter snake.*

making a home for grasshoppers, plant corn or oats and let it sprout before putting in the insects. For toads, use garden soil, a dish of water sunk into it, with perhaps some stones and a little grass. The toad will bury itself in the soil. Salamanders like moist moss and pieces of decaying wood under which to bury themselves. Lizards and horned toads will bury themselves in the sand of a desert terrarium.

The terrarium should be kept out of strong sunlight and in a place that is not too warm. It should be sprinkled with water when first made, if it has plants in it. After that it should be sprinkled only when the cover gets dry on the underside. Water should be kept in a dish if there are animals in the terrarium. Snakes go into water, and a tall container like a pint milk bottle or pickle jar of water will make them comfortable. A low dish is better for turtles and toads. This can be placed in one end of the

terrarium and stones and soil built up around it to the level of the top of the dish.

A single terrarium should not contain a large variety of animals. Since boxes of glass and adhesive tape are practical and inexpensive, it is better to have several, each one containing a different kind of animal. Gallon coffee jars make good containers.



*A woods terrarium.*

The food of frogs and toads in the wild state consists of insects, worms, caterpillars, snails, and slugs. They also eat flies, mosquitoes, and gnats. These can be easily provided, but they should always be alive. Frogs and toads will not touch dead worms or insects. They will starve in a terrarium if they have no live food to eat. A fly trap can be made and once a day the flies released from the trap into the terrarium. When there are insects out of doors, they may be caught by sweeping the grass with an insect net. In winter when flies are scarce, meal worms (the larvae of beetles), which can be cultivated in bran flour, may be substituted.

Newts and salamanders can be fed on bits of raw meat, fish, oysters, scrambled eggs, worms, or insects. Land turtles are plant-eaters, using tender plants and berries for food. Water turtles are meat-eaters, using earthworms, insects, crayfish, and small fish for food. Mud turtles eat under water. Horned toads eat living insects. Garter snakes eat earthworms, insects, frogs,

salamanders, and toads. Snails are vegetarians; lettuce is a good food for them.

Care should be taken that an excess of uneaten food does not remain in a terrarium. Terrariums should be kept clean so that the captive animals may live in healthful conditions.

## HOW TO MAKE AN AQUARIUM

Almost any container that holds water may be used for an aquarium, but a straight-sided one is best. The globe-shaped ones afford too little water surface for the absorption of air and they distort the shape of objects inside the aquarium.

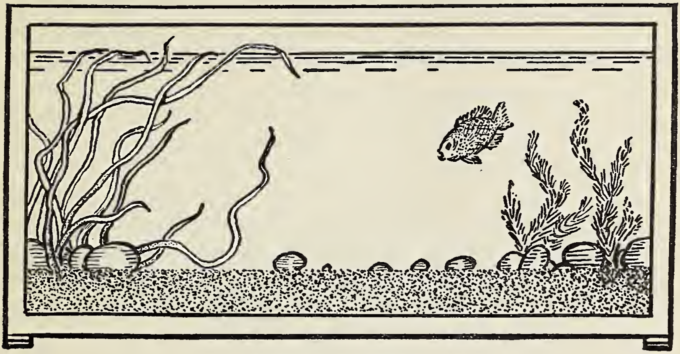
The container must be very clean, and the sand must be thoroughly washed. Sand may be washed by running a stream of water into the pan of sand until the water runs out clean. If the sand is then baked in an oven, any bacteria or mold spores will be killed.

Enough sand should be put into the bottom of the aquarium to insure a good root-hold for the plants. Elodea, eelgrass, and water milfoil are all good aquarium plants and are common in most of our fresh-water lakes and streams. These are satisfactory for summer aquariums but they do not always survive the winter. There are many inexpensive tropical water plants which can be used. Such varieties as Valisneria, Cabomba, Myriophyllum, and Sagittarium are commonly obtainable. It is believed that Valisneria is the best oxygenating plant. This is a grasslike plant which grows very quickly. Duckweed is a small leaflife plant that is often found floating on ponds. It is attractive in an aquarium, though it doesn't help to supply much oxygen.

The plants should be planted in the sand, then anchored with stones. Water can be poured into the aquarium without disturbing the plants by putting a piece of paper on the sand and pouring the water on the paper, or a dish may be placed on the sand into which the water can be poured.

Clean pond, lake, or rain water is best for an aquarium because it contains minute organisms that may later feed the animals. If tap water must be used, allow it to stand several days before putting it into the aquarium. This allows any lime that might spoil

the sides of the aquarium to be deposited and frees the water from any chlorine that has been added for purification. After adding the water, allow the plants time to become rooted before putting



*A simple aquarium.*

in the fish or tadpoles. Otherwise the animals may pull up the plants.

One rule for the number of fish in an aquarium is one three-inch fish to a gallon of water. Another rule is an inch of fish for each 20 square inches of water surface at the top. Most people are inclined to put more fish into an aquarium than the amount of water justifies.

Any kind of aquarium fish such as goldfish or tropical fish may be put into an aquarium. However, tropical fish are more difficult to keep than goldfish, and require more attention. The water temperature must be kept above 65° for tropicals, and the feeding must be more regular.

Of the tropical fish, guppies, swordtails, and paradise fish survive well and they have interesting habits. Guppies and swordtails are livebearers. Under favorable conditions, guppies reproduce every six weeks. The bubble-nests of the paradise fish are interesting. Tropical fish and goldfish should not be put together in an aquarium as tropical fish often kill the goldfish. Also the fighting paradise fish must be kept away from other tropical fish.

Some wild fish will survive in an aquarium and they make in-

teresting pets. Small sunfish, bluegills, and bullheads are examples.

Snails should be put into the aquarium to act as scavengers. They help keep the sides of the aquarium clean. Tadpoles will serve the same purpose. Clams also help keep the water clean. If water turtles and small frogs are put into an aquarium, they should be provided with flat pieces of wood onto which they can crawl and get out of the water for air.

The first rule in the feeding of fish is not to overfeed. Only a small amount of food should be given, or as much as will be consumed at that feeding. Food not eaten at once falls to the bottom of the container, sours, and makes the water impure. Goldfish can be fed as seldom as once a week. They should not be fed more than three times a week. Tropical fish should be fed three times weekly. A long glass tube may be used to remove bits of uneaten food. Place the tube straight down over the particle, close the upper end of the tube with a finger, and lift out.

Oatmeal (cooked), boiled white of egg, cream of wheat (cooked), liver (cooked), beef (cooked or raw), chopped earthworms, and flies are good food for both goldfish and tropicals. These foods are better than artificial food. Wild fish can usually be fed earthworms or chopped raw beef. They will also eat live insects placed on the surface of the water.

If the aquarium is balanced, the animals and plants will look healthy and the water will be clear. Cloudy or milky water is probably due to the spoiling of uneaten food, or to decaying plants. This water is bad for fish. Immediately remove the fish and clean the aquarium and replenish with fresh water. In changing fish from one container to another, keep water temperatures the same. Fish cannot stand sudden changes of temperature. Be sure also that tap water has been properly conditioned to remove chlorine. Allow it to stand for twenty-four hours before putting it into the aquarium.

Fish should be handled with a small net or lifted out in a dish of water. Grasping them with the hands is likely to break the film over the scales and permit fungus to get started. If a fish is diseased, remove it at once and put it into a solution of salt water, in proportions of one teaspoon of salt to a quart of water. It may remain in the solution for a period of several hours. Then put it

into a container of fresh water. Repeat the treatment every day until the fish is well.

The children will get much pleasure and profit from their management of both terraria and aquaria. There are many interesting aquarium books and magazines on the market to which they can turn for lists of animals and plants and for notes on feeding. Also in recent years there has been much interest in amateur tropical fish raising and many of the children may come from homes where there is a tropical fish enthusiast.

## HOW TO CARE FOR CATERPILLARS

Some caterpillars spin cocoons, some form chrysalids, some go into the ground to pupate, some spend the winter hibernating in the larval stage. In discussing them with the children, suggest that since the caterpillars they find may not be ready to pupate, they must be sure to bring in some of the leaves on which they find the larvae. Then you will know what to feed them. Caterpillars will leave food and hunt a suitable place when they are ready to pupate. Polyphemus caterpillars may be put into a glass jar that has some twigs with leaves on them. A piece of glass may be laid over the top of the jar. This prevents escape of the caterpillar and also helps keep the leaves fresh. If the caterpillar is still hungry it will eat the leaves. The jar should be cleaned each day and fresh leaves put into it. When the caterpillar is ready to spin, it will use the twigs and sides of the jar as its foundation and spin leaves into its cocoon. When the cocoon is finished, it may be removed from the jar and put into a cool place until spring. Jar and all may be put away. If it is kept in a dry place, the cocoon should be dipped in water once in a while.

Caterpillars like the tomato sphinx (tomato worm) go into the ground to pupate. There should be some garden soil in the bottom of the jar for them. A flower pot with a cylinder of wire screening over it is good, also. Some Woolly Bears hibernate in the larval stage so a terrarium with some dead leaves and pieces of bark makes a good home for them. They will spin in the spring. Some Woolly Bears spin in the autumn.

The Monarch or milkweed caterpillar forms a chrysalis. If the children bring any Monarch caterpillars in, put them into a jar

with milkweed leaves. When ready to pupate, they will spin pads of silk on the underside of a jar lid, leaf, or twig, then hang from it and shed the larval skin, leaving the green chrysalis. Since the caterpillars that form chrysalids in the autumn soon emerge, they may be left in the room for the children to watch. Chrysalids of butterflies that emerge in the spring may be cared for in the same way as the cocoons.

Fruit and salad dressing jars are just as good as more elaborate equipment. The main things to keep in mind are to have fresh leaves of the right kind which are kept from drying too quickly but are not wet, and not to have too much heat. After pupae are formed, they should be placed in a cool place, not moist enough to mold, but not dry enough to kill the pupae. Cleanliness in their care is important, as many caterpillars are susceptible to disease. Also when handling caterpillars, be careful not to bruise them. It is better to let them crawl onto a twig and then move the twig, than to pick them up with your hands.

## OTHER ANIMALS IN THE SCIENCE ROOM

The extent to which it may be desirable to keep animals in a schoolroom depends upon the size and facilities of the room, the interests of the children, and the kinds of animals you wish to keep. While some plants and animals if properly cared for are sure to make a room more interesting, we mustn't lost sight of the fact that the children are the most important occupants of the room. If having other animals makes the room less attractive or comfortable for the children, you should either do without the other animals, or choose animals that are easily kept in captivity and cared for.

Directions for the care of aquarium and terrarium animals have already been given. All these cold-blooded animals are clean in their habits and have little or no odor about them.

Small mammals such as rats, mice, guinea pigs, and rabbits may be kept in cages in the room if the cages are kept clean. Cages with removable metal bottoms are more easily cleaned than wooden ones. A cage may be made of an orange crate with a galvanized iron tray made to slide in the bottom of the box. One-

*Observing a turtle.*

half-inch mesh galvanized wire should be fastened to the open side and a sheltered corner should be made of a smaller box which is placed inside the cage. All animals need to have a place in which to hide.

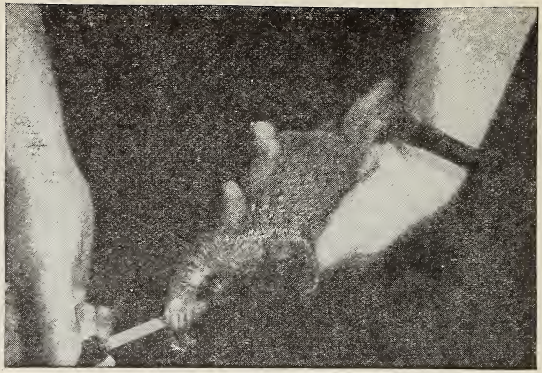
Sawdust or straw should cover the floor of the cage and be replaced with fresh material every day. If a layer of newspaper is put on the floor first, the cage can be more easily cleaned. The animal will carry some of the material into its sheltered corner.

Guinea pigs and white rats are more easily kept in a schoolroom than rabbits. Rabbits may be brought in for a day or two, but it is better for them to live out of doors.

These rodents may be fed oats, alfalfa hay, carrots, and other vegetables. The young ones should have milk and a few drops of cod liver oil each day during the time when they do not get plenty of sunshine. Evaporated milk diluted with warm water is more easily digested by these small mammals than is fresh milk.

If the schoolroom is closed and becomes either very hot or cold over the week-ends, the animals should be taken to the home of one of the children. Extremes of temperature are not good for warm-blooded animals, particularly when in captivity where they can't protect themselves.

Although many of these animals are able to get their water from



*Feeding a young squirrel.*

their food, water should always be provided in the cages. The container should be low enough for the animal to drink from and of a kind not easily tipped over.

Wild rodents, such as meadow mice, squirrels, and chipmunks are sometimes brought into the schoolroom. Adult wild animals are difficult to tame and often refuse to eat. Young wild rodents, however, may be cared for and make interesting pets. If they are very young they may be fed on warm, diluted evaporated milk. The smaller the animal the more warm water should be added to the milk, the more frequently it should be fed, and the less it should have at each feeding. One needs to use common sense in caring for these young animals. Keep them warm, let them alone as much as possible, and don't overfeed them.

Children sometimes bring other young mammals to school. Until the animal is old enough to eat solid food, its care is the same as for the other animals mentioned above. Teachers may find detailed directions for rearing all kinds of wild animals in Moore's *Wild Pets.* See reference list.

Young birds are easily reared if you know the food to give them. Any good bird book will tell the food of the common species of birds. Insect-eating birds may be fed earthworms, caterpillars, and small larvae of beetles. Hard-boiled eggs may be substituted

for part of their food. The shells should be crushed and fed with the egg. Young flickers may be fed raw eggs and ants.

Seed-eating birds may be fed any kind of small seeds. Chick-feed is easily obtained. Some bread may be given them but should be supplemented with seeds. All birds need sand and other hard foods.

When a bird is first found it may have to be fed forcibly. Open its beak gently and put the food in the back of its throat. A pair of forceps or tweezers is useful in accomplishing this. The bird won't swallow unless the food touches the swallowing center on the back of its tongue.

Fish-eating birds such as bitterns and loons are occasionally found and brought to school. These are problems to feed as they do not thrive on dead fish. The author has successfully fed young fish-eating birds on live tadpoles and minnows.

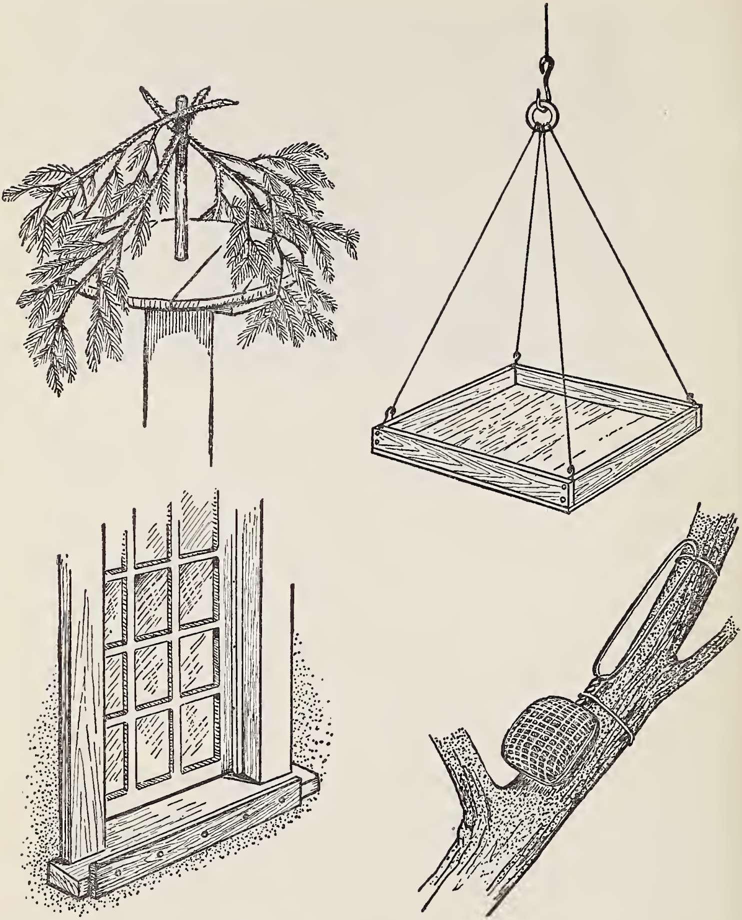
Hawks and owls may be fed pieces of meat which have been wrapped in cotton or rolled in sand. These birds should be handled with care as their bite is painful. Young ones soon learn where their food is coming from and open their mouths.

Unless a wild animal is too young to care for itself, it is wise to keep it awhile for study and then release it. School buildings are not built to house the lower animals. A trip to a well-run zoo will demonstrate how varied are the needs of the different groups of animals. It would be impossible to duplicate these conditions in a room where children live. A cage built outside a window on a level with the window sill will partially solve the problem. If a squirrel or rabbit is to be kept for any length of time this might be worth while.

In caring for any animal, the children should be made to feel responsible. They should read about the natural habitat and food of the animal and try as nearly as possible to duplicate these conditions. Even though some animals die, the value to the children makes caring for them worth while.

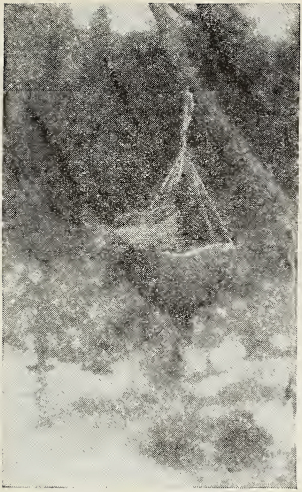
## WINTER BIRD FEEDING

In the northern part of the United States most of the common birds migrate in the autumn but there are a few that remain through the winter. Why birds migrate is a question no one has



*Simple feeding stations for birds.*

solved satisfactorily, although there has been much written on the subject. The teacher should familiarize herself with the theories of migration and not try to solve the problem.



*Half a coconut may be filled with melted fat.*

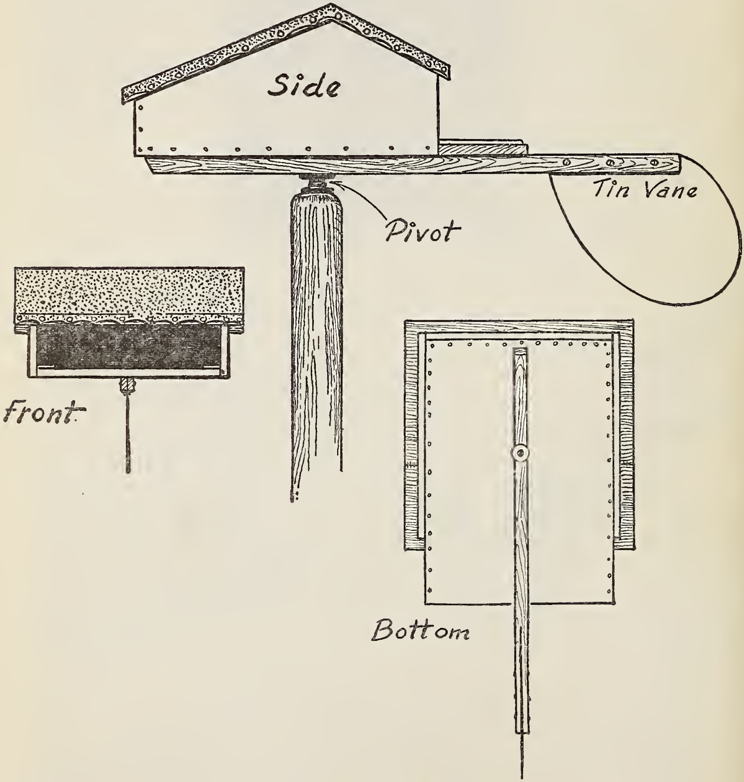
Some winter bird residents stay the year around in the north. Among these are the chickadees, nuthatches, and downy woodpeckers. Others come from farther north, spend the winter, and return to their northern nesting grounds in the spring. Brown creepers, juncoes, and tree sparrows are examples of these.

Some winter birds are insect-eaters and some feed on seeds or fruit. The downy woodpecker is able to chisel through the bark of a tree and with its tongue spear the larvae underneath. Nuthatches and brown creepers get insect eggs and insects from the crevices in the bark. Chickadees and titmice find their insect food mostly in the buds and on the twigs of shrubs or trees. But in winter, all of these will eat whatever they can find. Since they are meat-eaters, we put suet or nuts on the feeding shelf for them. To prevent suet from being carried away by a blue jay or starling, it may be put into a wire basket made of coarse screening.

A soap shaker may be filled with suet and hung from a wire. The suet may be tacked to a tree or tied to a limb. The nuts

should be crushed or finely cracked to prevent squirrels from carrying them away. Birds will scratch among the shells and pick up the bits of nut meats. Walnuts or hickory nuts are good bird food, and may be gathered by the children in the autumn, to save for winter feeding. Half a coconut may be filled with melted fat and hung from a branch. Cracked nuts or seeds may be added to the fat.

Juncoes, sparrows, goldfinches, and cardinals are seed-eaters.




*A more elaborate feeding station.*

Any seeds, such as wheat, oats, millet, or cracked corn, will attract them. Sweepings from a mill are welcomed by birds and they will scratch in the chaff for days, finding tidbits. Cardinals and grosbeaks are especially fond of sunflower seeds. Crumbs of any kind will attract birds, as will berries and pieces of other fruits. The children can put out discarded apple cores and cranberries. Breakfast food or other cereals which might be discarded because of weevils are good bird food. Even weed seeds are attractive to birds. Dried fruit will attract some birds.

Shrubs with berries on them always attract birds. Among these are snowberry, barberry, high-bush cranberry, wild plum or cherry, and bush honeysuckle. Teachers who have anything to do with landscaping the school grounds should see that some such shrubs are planted.

A simple shelf is as effective as a more elaborate one. Just an extension from the window will work, although a roof prevents snow from covering the food. The birds may not come at first, so a good way to get them started is to sprinkle some grain on the ground under the shelf. The sparrows will come first and though we do not care so much for them, they show the other birds the way. A dry doughnut dangling at the end of a string will provide entertainment equal to circus acrobats. Peanuts fastened to a string stretched across the window or between trees will also attract birds.

A swinging shelf usually frightens sparrows and drives them away. However, for teaching purposes in the primary grades even an English sparrow has possibilities.

In snowy, freezing weather, water is as hard for birds to get as is food, so water should be put out for them each day. It will often attract birds not attracted by food. A shallow earthenware container like the saucer of a flower pot is good for this purpose.

## FIELD TRIPS

If properly conducted, a field trip may be an important activity to help in the solving of some science problem. Improperly conducted, it may be a waste of time.

A field trip must have purpose. It must come as a result of a need to learn something outside the schoolroom. It need not mean

*A field trip—looking for birds' nests.*

a long trip. For example, in a discussion of soil formation the question may arise of whether freezing and thawing break up rock and form soil. To illustrate this, the children may go outdoors and find rocks that have been cracked in this way. Even sidewalks and the foundations of buildings illustrate the point.

The teacher should anticipate any trip she plans and make the trip herself before she takes the children. If she intends taking the children to see birds, she should make sure that there will be birds to see. Birds are elusive and cannot be tagged and made to stay in one place. But a nest that is being built, or the work of a woodpecker located by the teacher or some member of the class, will remain until the whole class sees it. The chances of also seeing the bird will be good. With a definite objective in mind, the teacher is sure to prevent disappointment and aimless looking.

Before starting on a trip, the teacher must be sure that every

*A field trip—locating territories of birds.*

child knows what he is going to look for. There is endless variety in the number of interesting things to see out of doors, but unless the attention is directed to a few, there will be confusion, and no learning will result.

For example, on the way to a river to see erosion, the group may watch for terraces that have been made as the river cut down to its present bed.

A large group should be organized into small units with a leader for each. These may be working on the same problem or different problems. If unusual things are found, the whole group may be called together to see them.

A simple way to organize groups is to make enough slips of paper for each member of the class. Number them from one to five. Circle one of the number ones, one of the twos, one three,

*After a field trip—rock study.*

one four, and one five. Have the children draw slips. All the ones make a group. All the twos make a group, and so on. The children with the circled numbers are the leaders for the day.

Children like to make their own rules for field trips and take pride in following them. Here is a set of rules made by a third-grade class before going on a trip to study birds.

1. Walk quietly. No loud talking.
2. Follow your leader.
3. When you see a bird, stop. When the leader stops, everyone stops.
4. When you see a bird and want to show it to the rest of the group, tell them, without pointing, where it is. (Birds see better than they hear and are startled by quick motions.)
5. When you are looking at a bird, stand with your back to the sun.

Too many rules are confusing just as too many directions are. It is better to take short trips at first, trying out one rule; then add more rules as longer trips are taken. If the children understand what the trips are for, they will gain the proper attitudes toward them.

It is very important in any science work to respect the discoveries and ideas of children. When they see or find things on a trip, the group should give as serious attention to them as to the teacher's contributions. This encourages children to observe and it intensifies their interest.

On a collecting trip, enough containers should be taken along to carry back any specimens. Directions on how to collect and what to collect should be clearly understood before leaving the school. Collecting should be done only when material collected is to be used. If such material may be studied to better advantage in the schoolroom than out of doors, it serves a purpose. But only as much as is needed should be taken. Gathering hundreds of frogs' eggs would be wasteful when a few would be all the children could care for. It is better to raise a few tadpoles to adulthood than to have dozens die for lack of room or food.

Some of the types of trips may be listed as follows:

1. A trip to locate territories of birds. Return at regular intervals to watch nest building and rearing of young.
2. A trip to collect rocks.
3. A trip to see types of erosion.
4. A trip to find tracks of animals.
5. A trip to find and collect galls.
6. A trip to a zoo or museum to see something that has been discussed in class, such as fossils.
7. A trip to a meadow to collect weed seeds.
8. A trip to observe the sky.

The suggestions for teachers that are given later in this manual list other ways to give purpose and variety to field trips. Trips should never grow so common or become so regular as to be monotonous, nor so dull as to be meaningless. Children should always regard them with enthusiasm, not because they offer an opportunity for play, but because they are the most satisfying solution to many of their science problems.


# *THE HOW AND WHY SCIENCE BOOKS*

## BASIS FOR CHOICE OF MATERIAL

### CHILDREN'S INTERESTS

Children's interests were closely studied in preparing and organizing the material used in THE HOW AND WHY SCIENCE BOOKS. The subject matter was used by the authors in actual teaching experiences over a period of several years and with many different age groups of children. The problems were used in mimeographed form until arranged for publication.

### RECENT COURSES OF STUDY

The material for the books was originally chosen from units that appeared in many courses of study from many sections of the United States. City and state courses of study were consulted, as well as those prepared and used in teacher-training institutions. More recent studies, problems which have arisen in the classes of the authors, and new courses of study have added new material to the original series.

## THE THIRTY-FIRST AND THE FORTY-SIXTH YEARBOOKS

The outlines for science in the elementary grades found in the *Thirty-First Yearbook* and in the *Forty-Sixth Yearbook* of the National Society for the Study of Education have been closely followed. Some quotations from the *Forty-Sixth Yearbook* are of interest here:

"Instruction in science should begin as early as children enter school; activities involving science should be provided even in the pre-school and the kindergarten. Through the sixth grade the work in elementary science should consist of a continuous integrated program of the sort advocated by the *Thirty-First Yearbook.* Such a program should provide an expanding, spiral development of understandings, attitudes, and skills, as prescribed in chapter iii."—pp. 41–42

"It is most important that the material selected for each grade of the primary school be balanced to include the elements of learning which represent a rich experience with science. Each level should give the child some opportunity for exploration with content derived from the great major fields of science: astronomy, biology, geology, and physics. This cannot be accomplished by studying only plants and animals.

"There should also be balanced instruction as to the types of activities employed. Children should have a rich opportunity to develop their abilities in discussion, in experimentation, in observing in the out of doors, and in reading for information and motivation. A complete program of instruction in primary science can be maintained only by the full utilization of all these activities, for each plays its part in the development of the purposes of science education."—p. 84

"Since experimentation involves 'learning by doing,' there can be no substitute for it. Pupil experimentation is an essential part of science education. In every course of science offered at any level, therefore, opportunities should be provided for pupils to perform experiments." —p. 53

"The basic purpose of the elementary school is the development of desirable social behavior. Science, with its dynamic aspects, its insistence upon critical-mindedness and better understanding of the world, and its demand for intelligent planning, has a large contribution to make to the content and method of elementary education.

"To accomplish this basic purpose a continuous program of science instruction should be developed throughout public school education, based upon a recognition of the large ideas and basic principles of science and the elements of the scientific method. Children must be given opportunity to gain the knowledge necessary for intelligent and

cooperative experience with the world of matter, energy, and living things and to develop constructive appreciations, attitudes, and interests. This demands that the individuals in our society become intelligent with reference to the place of science in individual and social life.

"When the content and method of science are examined, it is found that the child's normal activities have much in common with the purposes of science in modern society and that the teacher can view the teaching of science as utilizing the natural dynamic drives and potentialities of children."—p. 73

"Work in the primary grades should not be exhaustive. Rather the child should feel that there is more to learn about everything that he does. A developmental point of view demands that a well-balanced program provide contacts with realities. It cannot allow omissions in the development of the concepts, principles, attitudes, appreciations, and interests derived from the field of science."—p. 82

"The new program of science, which emphasizes the development of desirable social behavior, is organized around problems that have social value and are challenging and worth while to children. The teacher must, therefore, look back of the objects of the universe to the problems which involve meanings that the children will need to understand in order to participate intelligently in life. This means that, in science, opportunities must be provided for the development of understandings in all the areas of the environment and at all levels of social needs."—p. 92

## HEALTH, SAFETY, CONSERVATION, AND AERONAUTICS AS INTEGRAL PARTS OF A SCIENCE PROGRAM

The authors of THE HOW AND WHY SCIENCE SERIES have made health, safety, conservation, and aeronautics integral parts of the science program. This is in accordance with the recommendations of the *Forty-Sixth Yearbook*:

*"What is the place in the science curriculum of conservation, aeronautics, physiology, and health education?* The materials of these areas are of value chiefly for general education. Except, perhaps, for an eighth-grade one-semester course in health and physiology, it is probably not desirable to offer separate courses in any of these subjects. Their materials can be more effectively integrated with those of the regular courses of the science sequence and with other courses in the program of studies."—p. 46

"The content of the science program in many elementary schools is now being organized around problems which have social value and which are significant in the lives of children. These problems arise from children's

interest in the world around them and from their need to meet intelligently their problems of living in areas such as health, conservation, and safety. They are solved not through the mere accumulation of facts but in such a way as to help children (1) develop meanings which are essential to social understanding, and (2) put into practice desirable social behavior. Problems involve meanings in their solution, and meanings are learned through experiences."—pp. 69–70

"A program in science should develop a large background for the teaching of health. Many schools are now integrating health entirely with science and the social studies. Science provides much of the background for the teaching of health facts and the development of health habits. Moreover, in their study of science, pupils should gain a vision of the potentialities of science in the improvement of the health of the nation and the world."—p. 76

"Likewise, science is involved in accident prevention and safety instruction. We cannot fully anticipate the environment of the future. New inventions may eliminate present hazards and create new ones, making it impossible to develop a code of conduct in safety instruction which will be functional for an entire life span. It may be well, then, in safety instruction to place more emphasis upon the scientific principles which are basic to safe conduct."—p. 77

"The place of science in bringing about the wise utilization of natural resources to the welfare of mankind is an important aspect of the science areas related to the social needs."—p. 77

### HEALTH

The study of health in our public schools should be an integral part of the science program. To study health without its scientific basis is to leave the study without form or background. This fact can be illustrated by examining almost any phase of the teaching of health. Let's start, for example, with respiration.

We teach that man breathes air. In his lungs the oxygen from this air passes through the walls of the capillaries into the blood. Here because of hemoglobin in the red corpuscles, oxygen is taken with the blood to the heart and then to all parts of the body. The oxygen enters the cells. There it is united with food material that comes through the digestive tract and the blood. The food is oxidized, producing heat and other forms of energy. This is a simple little statement that one might find in a health book. Where does the oxygen come from? What is it like? What are its properties? These are science problems.

Botany teaches us that plants use carbon dioxide in making food and give off oxygen. All green plants do this. This is where part of our supply of oxygen comes from. Chemistry teaches us the properties of oxygen. It also teaches us about oxidation. It is important to know that the uniting of oxygen with other materials forms new chemical combinations. This makes it possible for the student to understand what happens in the human cell when oxidation takes place. He discovers that heat and other forms of energy are produced. In order to understand heat and its relations to other forms of energy one must understand physics. This involves the physical properties of heat, energy, and the passage of energy from one form to another.

Oxidation in the cells produces energy and gives off carbon dioxide. Carbon dioxide dissolves in the blood, is returned to the lungs, and breathed out. The student who reads the story of respiration in a health book given to health must consult botany, chemistry, and physics in order to understand the story intelligently, or the health book must contain much science material.

The student who has studied respiration as taught in the HOW AND WHY BOOKS knows the scientific background of every step of the process; hence, he can understand the interrelationship between plants and animals. In fact, respiration becomes an intelligible story. Respiration cannot possibly be taught as an isolated phenomenon. It must be incorporated into a book covering all phases of science to be intelligible.

How does the body grow? It grows through cell reproduction. A student who understands this must understand the meaning of the word *cell*. In science this concept is developed in connection with one-celled animals and plants. The student who knows how a cell divides to form two, and the two further divide to form more cells, and how each cell is composed of a cell wall, protoplasm, and nucleus is ready to understand how the epithelial cells of the skin and mucous membranes divide and grow to cover the body. It would be impossible to teach the concept of human cells without giving a scientific background.

Another example is that of the study of digestion. Digestion begins with food. To understand digestion one must know about the various types of food. One must understand the character-

istics of each kind of food. One must know the unique function that each kind of food has in the body. In science children study these foods. They study the relation of animals to food. They study the relation of energy to food. When they have questions concerning their own digestions, they have an intelligent background of understanding. Let's take an example. A child puts some potato into his mouth. If he has studied the science of plants, he knows that a potato is a tuber. He knows that it is made up of about ninety-five per cent water and some starch. He knows, therefore, that when he starts to chew the mouthful of potato, he mixes it with saliva. He knows that there is a material in saliva which changes starch into sugar. This is a chemical change. The potato passes through the esophagus into the tomach. Here it is further mixed with other digestive juices, and the starch is completely digested into a soluble sugar. This sugar in solution passes through the walls of the intestines by the process of osmosis. What is osmosis? Osmosis is something one learns about in physics. It has to do with the pressure of different fluids and their passage through a membrane. The food travels in the blood to the cells of the body where it goes through the chemical process of oxidation. How would one teach food and digestion if he had to teach it without science? There is nothing in the program of health that can be taught as an isolated fact and be intelligible.

Let's look as muscles. Of course we must teach about muscles. We must know about cells to understand how muscles are made. How do muscles act? In the first place they get their energy by the oxidation of food in the cells. This process cannot be understood unless one understands chemistry. By using the energy produced by oxidation the muscles contract. When the muscles contract, they move the bones. To understand how they move the bones it is necessary to know some physics, because the muscles that move the main structure of the skeleton work on the law of levers as developed in physics. Muscular activity involves the laws of both chemistry and physics.

If we turn to the senses, it would be impossible to even attempt an explanation of how we see without some conception of the physics of light. It would be impossible to understand the use of glasses unless one knows the laws of refraction that are taught in



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physics. It would be impossible to know how the eye functions to focus the light on the retina and understand what happens to light waves as they pass through certain types of media. We must have some knowledge of the physics of sound and how the vibrations work to understand how the process of hearing takes place.

Health principles are based on scientific fact. The How and Why Science Books have put the health program in the science field where it belongs. The development of science concepts throughout the books advances the basic health rules logically and naturally.

SAFETY

Safety is taught both in connection with health and as a part of scientific procedure. In the intermediate books of The How and Why Science Series the following concepts contribute to an understanding of principles of safety.

*The How and Why Club*:

| | | |
|---|---|---|
| pp. | 5 | Care in riding bicycles on the highway. |
| | 6–9 | Safety regulations at an airport. |
| | 40 | Safety in using chemicals. |
| | 80 | Recognition of the only poisonous spider in the United States. |
| | 159–174 | How to keep food from spoiling. |
| | 176–179 | Pasteurization. |
| | 197 | How to tell directions at night. |
| | 237–243 | Safety in using tools. |
| | 245–247 | Protection of the eyes from the sun. |
| | 315 | Avoiding danger from lightning. |
| | 324 | Use of fuses to prevent fires. |

*How and Why Experiments*:

| | | |
|---|---|---|
| pp. | 26–29 | Harmful fungi and bacteria and how to eradicate them. |
| | 89–91 | Man's protection against weather. |
| | 112–115 | Protection against insects that carry disease. |
| | 116–121 | Immunization against diseases. |
| | 167, 168, | 170 and wherever fire is used in an experiment. Safety rules for using fire. |

| | |
|---|---|
| 209 | How to make and use a fire extinguisher. |
| 210 | How to avoid carbon monoxide poisoning. |

*How and Why Discoveries*:

| | |
|---|---|
| pp. 42 | Use of alcohol on a needle to kill bacteria. |
| 251–252 | How a rescue bell works. |
| 289–293 | How water can be purified. |
| 305 | Use of electrical switches. |
| 313–315 | Protection from electricity. |
| 355–374 | Prevention of disease. |

CONSERVATION

Many activities in science may contribute to the objectives of conservation education.

Dr. Ira N. Gabrielson, director of the Fish and Wildlife Service of the U. S. Dept. of Interior, in his book *Wildlife Conservation* says, "the various programs for the conservation of soil, water, forests and wildlife are so closely interwoven that each vitally affects one or more of the others. All are phases of a single problem —that concerned with the restoration and future wise use of our renewable natural resources. . . . The term 'conservation,' when applied to the two classes of renewable and nonrenewable resources, carries quite different meanings. The conservation of the inorganic or nonrenewable resources, such as coal, iron, copper and oil, means sparing use with no waste. The conservation of organic resources implies use, but only to an extent that will permit a continual renewal."

The scientist's concept of conservation has changed in the last few years and broadened to include not only minerals and wild life but human resources as well. It is with this last resource that elementary teachers are most concerned. To conserve human life and well being for future generations, it is particularly important that we take thought today. The children we are teaching are facing a very uncertain world, politically and economically. Someone has said "Our children are living in the world of today, we are not." We need to take stock of our curricula and see whether or not this is true. Are we teaching the things that are vital to the preservation of the race or are we still clinging to the patterns we ourselves were taught to follow? If conservation is vital to the

preservation of man, how can we make it a vital part of our science program?

In the first place we must find natural ways in which the problems of conservation fit into the lives of the particular groups we teach. Suggestions have been given in various places in the intermediate books of the HOW AND WHY SCIENCE SERIES for discussing conservation of plants, animals, soil, and water. The ways that arise will depend upon the conservation needs of the region. In one region it might be soil, another game, another water, another forests. In a crowded city district it might be utterly out of place to discuss wild-life conservation with children who lack food and sunshine. Ways and means of helping these children to build strong bodies would obviously be the conservation program needed there.

Teachers need to be careful not to become so enthusiastic about the subject of conservation as to forget that they are teaching children, not subjects. As adults we should be much concerned about the future and its resources. Children cannot and probably should not be confronted with such remote problems. If the best trained men in the country have been able to do little about soil erosion and flood control, certainly children can't attack the problems.

But children can see what rain and melting snows do to their lawns and terraces. They can see the results of malnutrition in other children. Pictures of the children in starving countries continually bring this to mind. They can attack problems of plant and animal interdependence as suggested in various units in the HOW AND WHY SCIENCE BOOKS. The attitudes, habits, and appreciations gained in these units may be easily made a part of a conservation program.

Concepts contributing to an understanding of conservation are taught in the following chapters of the intermediate books:

*The How and Why Club*:

| | | |
|---|---|---|
| pp. | 44–59 | How Beavers Live |
| | 73–83 | A Spider's Bridge |
| | 84–87 | More About Spiders |
| | 89–93 | Plants Depend on Animals |

| | |
|---|---|
| 94–107 | Animals Depend on Plants |
| 116–127 | Foods the Body Needs |
| 164–174 | Why Does Food Spoil? |
| 176–179 | Pasteurized Milk |
| 225–235 | Weather Changes Rocks and Soil |
| 282–289 | Some Drummers |

*How and Why Experiments*:

| | |
|---|---|
| pp. 5–15 | How Weeds Grow and Survive |
| 30–56 | Birds Migrate |
| 64–76 | The Struggle Among Living Things |
| 102–116 | Why Man Destroys Some Insects |
| 246–255 | How Plants and Animals Live Together |
| 292–302 | Use—Don't Waste |
| 326–335 | Feathered Mouse Catchers |

*How and Why Discoveries*:

| | |
|---|---|
| pp. 193–205 | Enemies and Friends of Health |
| 219–228 | Conservation of Wild Life |
| 284–294 | The Importance of Water to Man |
| 355–372 | How Our Health Should Be Safeguarded |

AERONAUTICS

Although World War II gave an added importance to the subject of aeronautics, and a considerable number of separate courses in this field are being taught, chiefly in the senior high school, the authors of The How and Why Science Series believe that this subject can be more effectively integrated with the regular science course. Beginning in the Pre-Primer, the books of the series provide valuable and adequate instruction about the science of flight. Again, this material takes its place as a part of the science program in the study of air and its properties.

In the intermediate books, the following concepts contribute to an understanding of aeronautics.

*The How and Why Club*:

| | |
|---|---|
| pp. 6–16 | Airplanes land on special landing fields.<br>Airplanes have many safety regulations and devices. |

Pilots must obey signals and regulations for their own and their passengers' safety.

Passengers, visitors, and the ground crew must also obey safety regulations.

Weather is one of the most important factors in flying.

A pilot must know the direction and force of wind before landing. He must also know which runway to use.

Red and green lights are used to signal when a plane is to land.

The important parts of an airplane are: propeller, engine, landing gear, fuselage, wings, ailerons, elevator, rudder, nose, and stick.

197 The stars have helped guide aviators to safety.

*How and Why Experiments*:

pp. 175–177 Four main forces that act upon an airplane are gravity, lift, thrust, and drag.

The force of gravity is overcome by lift.

The wings of an airplane are built so that the pressure on the top of the wing is less than the pressure on the underside. This produces lift.

The force that moves the plane along the ground is thrust.

Drag, the force trying to hold the plane back, is caused by the resistance of the air to the forward movement of the plane.

*How and Why Discoveries*:

pp. 169 Weather presents many hazards to the aviator.

187 To determine the speed and direction of the wind, weather observers send up a radiosonde consisting of a balloon which carries instruments to measure temperature, pressure, and humidity.

188–189 Air travel is made possible by constant use of weather predictions.

All air travel is controlled by the Civil Aeronau-

tics Administration. No clearance will be given any plane unless the weather report is favorable.

270–279 A balloon will rise when the air inside the balloon is much lighter than the air in the atmosphere surrounding the balloon.

A dirigible is equiped with an engine that drives it forward, and a steering device.

A helicopter is a powered plane with rotating wings connected with the engine.

An autogiro is similar to a helicopter. The engine is connected with a propeller and the rotor is set in motion by the action of the air and the movement of the plane.

A glider is a heavier-than-air craft having no power, no engine, and no propeller. When launched, it is carried by wind currents and updrafts of air.

A parachute is used to check the fall of a jumper.

## THE PLAN OF THE INTERMEDIATE SERIES

### THE ORGANIZATION OF MATERIAL

The intermediate books of the How and Why Science Series enlarge upon the concepts presented in the primary books and introduce new ones. An effort has been made to show how the simpler concepts contribute to more complex concepts and principles. The material is organized around major problems which might easily grow out of children's questions if properly introduced.

### THE SCIENCE CLUB

The idea of a science club as introduced in The How and Why Club may be used to advantage throughout the intermediate grades. A science meeting at the beginning of each class period gives the children an opportunity to relate the experiences they have had outside the classroom. It gives them training in conducting a meeting of their own, and thus contributes to their social development. It helps develop their curiosity concerning their

environment and ability to observe accurately. It gives them an opportunity to ask questions and thus gives the teacher an excellent key to their natural interests.

### ILLUSTRATIVE MATERIAL

Environment and individual differences play such an important part in children's science interests that the teacher must be guided by her own group in the choice of problems. Some problems may have to be teacher-motivated because lack of experience on the part of her group may mean that the children will not initiate them. Once introduced to the material, children should accept it with interest, otherwise it is not suitable for them.

Illustrative material should come primarily from the child's own environment, but not exclusively so. In this regard the *Thirty-First Yearbook*, page 148, states:

> "Some have contended that no illustrative material should be used except that which is in the natural environment of the school. This seems to be a very narrow interpretation of illustrative material. In this day when the child listens to the events happening in Antarctica, or other far parts of the earth, in which his environment is spreading out so that the whole world comes into his own home in one way or another, to restrict the illustrative material to local, indigenous objects seems, indeed, to be inexcusable."

### THE COMPANION BOOKS

There is a Companion Book to accompany each of the texts. If used as designed, these Companion Books should help attain the following objectives:

1. The extension and enrichment of science concepts and interests.
2. The development of scientific attitudes.
3. The further development and understanding of the scientific method of problem solving.
4. The clarifying and fixing of correct science concepts.
5. The promotion of language growth.

In the intermediate grades, these objectives may be achieved in many ways. Some of the methods used in the Companion Books are applying concepts to new situations, solving problems, re-

cording data gathered through experimentation or field trips, making charts and maps, working puzzles, and taking objective tests of various types.

The authors are convinced that as the children acquire more skills, new learning should take place—that the Companion Books should not be just testing programs but an application of principles and concepts to new situations; that the lessons should require the using of skills which are necessary in gathering scientific data and solving problems to attack problems similar to those the children have read about in the text. In addition, the books provide interesting, individual activities for summarizing, testing, and recording group work in science.

FILMSTRIPS

A number of filmstrips have been prepared to correlate with the books of The How and Why Science Series. These extend and enrich certain concepts presented in the books, and enable the teacher to achieve her objectives more easily, quickly, and successfully.

The filmstrips have been prepared in series, with three strips in each series—on primary, intermediate, and upper-grade levels. For example, in the series on Weather, Filmstrip #1 ("We Learn about Weather") is designed for the primary grades; Filmstrip #2 ("Changes in Weather") is designed for the intermediate grades; and Filmstrip #3 ("Understanding Weather Conditions") is designed for upper grades. The strips are available singly or in series. Further information about them will be sent upon request.

## AN OUTLINE SHOWING THE DEVELOPMENT OF CONCEPTS

Although each Teacher's Manual contains a detailed outline for a year's work, the plan and organization of the three intermediate books of The How and Why Science Series are shown in chart form on the next two pages.

A large, more detailed chart is published separately. In this separate chart the horizontal development shows in more detail the growth of the concepts, and the vertical columns present more elaborate outlines of the material covered in each book.

| *Content Areas* | *The How and Why Club—Book IV* |
|---|---|
| LIVING THINGS<br>ANIMALS<br>(*See also detailed chart published separately*) | Animals have structural characteristics and habits which have made it possible for them to survive.<br>Many animals are very important to man. |
| PLANTS<br>(*See also detailed chart published separately*) | Plants have characteristics and life processes which have made it possible for them to survive.<br>Plants are very important to man. |
| THE BALANCE OF NATURE<br>(*See also detailed chart published separately*) | Plants and animals depend upon each other. |
| PHYSICAL ENVIRONMENT<br>WEATHER<br>(*See also detailed chart published separately*) | The weather affects the surface of the earth. |
| THE SOLAR SYSTEM<br>(*See also detailed chart published separately*) | The sun and moon affect the earth.<br>Some constellations we see in the winter sky. |
| EARTH STUDY<br>(*See also detailed chart published separately*) | The surface of the earth is continually changing.<br>Fossils. |
| FORMS OF ENERGY<br>(*See also detailed chart published separately*) | Heat is important to us.<br>Light is important to us.<br>Magnetism helps us.<br>Electricity is important to us. |
| AVIATION<br>(*See also detailed chart published separately*) | Aviators must follow regulations.<br>A plane is built to fly. |
| HEALTH<br>STRUCTURE AND CARE OF THE BODY<br>(*See also detailed chart published separately*) | The teeth are important parts of the body.<br>Bones and muscles are important.<br>Our bodies need fresh air. |
| FOOD AND DIGESTION<br>(*See also detailed chart published separately*) | The body needs food for growth and energy.<br>Foods have to be digested before the body can use them. |
| BACTERIA AND DISEASE<br>(*See also detailed chart published separately*) | Foods should be kept from spoiling. |

| *How and Why Experiments—Book V* | *How and Why Discoveries—Book VI* |
|---|---|
| Animals have modifications and life processes which have made it possible for them to survive. | Animals are continually struggling for existence. The most important factor in the struggle is food. Animals are able to get food by means of special structures that fit them to the particular food they eat.<br>Animals use food for growth and energy.<br>Species of animals have survived because of these modifications and life processes.<br>Water birds are especially fitted for life in or near the water.<br>Other water animals are adapted for life in or near the water. |
| Plants have modifications and life processes which have made it possible for them to survive. | Plants grow and reproduce by means of cells.<br>Water plants have characteristics which enable them to live near or in the water. |
| Man has upset the balance of nature by destroying wild life. | Man is now trying to repair the damage he has done to the balance of nature by conserving wild life.<br>There is an interdependence between the plants and animals in a pond. |
| The factors involved in weather are air, sun, and water. | The Weather Bureau helps us by forecasting the weather. |
| The movements of the earth affect our lives. | The earth is a part of the universe.<br>The earth belongs to the solar system.<br>The earth and the moon.<br>Besides planets and stars, there are other heavenly bodies.<br>Astronomers use many instruments in studying the sky. |
| | The story of the earth.<br>The importance of minerals to man. |
| Heat is produced in several ways.<br>Air is used by man to do work.<br>Electricity causes lightning.<br>Machines make work easier.<br>Sound is important to us. | Man uses air in many ways.<br>Water is important to man.<br>Magnetism and electricity.<br>Sound is an important form of energy. |
| Planes use air pressure to fly. | Man travels through the air in several ways. |
| The skeleton does important work.<br>The muscles do important work.<br>The nerves do important work.<br>The body needs care if it is to work well. | The skin is made up of cells.<br>The body needs care if it is to build up resistance to disease. |
| Foods keep our bodies warm.<br>Foods have to be digested and circulated so they can produce energy. | Human beings eat for energy.<br>The relation of water to health. |
| Bacteria are plants that are important to man. | The community health should be safeguarded.<br>Diseases have causes. |

# *THE HOW AND WHY CLUB—BOOK IV*

## SCIENCE PROBLEMS

Problem I. How do airplanes function as a part of transportation?
- A. How do the various parts of the airport work together?
- B. How does an airplane work?

Problem II. How do plants store food?
- A. Where do plants store food?
- B. How can we find out that these plants store food?
- C. What are some kinds of food that plants store?

Problem III. How do we use chemicals every day?
- A. What is meant by chemical change?

Problem IV. How do some animals use the food stored by plants?
- A. How do beavers and muskrats make use of food stored by plants?
- B. How do other gnawing animals make use of food stored by plants?
- C. How do the teeth of different animals help them eat the food they need?
- D. How do the teeth of human beings help them eat the food they need?

Problem V. How do spiders work?
- A. What are the habits of spiders?
- B. How do spiders compare with insects?
- C. What are some different kinds of spiders?

Problem VI. How do plants and animals depend on each other?
- A. How do land animals and plants depend on each other?
- B. How do plants and animals depend on each other in a balanced aquarium?
- C. How does nature balance itself?

Problem VII. How does the body work?
- A. What constitutes the framework of the human body?
- B. What makes the bones of the skeleton move?
- C. What are the foods we need?
- D. What must happen to foods before the body uses them?
- E. Why are grains cracked or ground before we eat them?

Problem VIII. How do we know about the animals and plants of long ago?
- A. How can we find out what animals and plants lived long ago?
- B. How do animals and plants of the past compare with those of today?
- C. How can we tell that at certain periods there seemed to be more of some kinds of animals and plants than of other kinds?

Problem IX. How should we care for food?
  A. Why does food spoil?

Problem X. How do animals spend the winter?
  A. How can we learn about the winter activities of animals?

Problem XI. How can we learn about the winter sky?
  A. What are some winter constellations?

Problem XII. How do the sun and moon affect the earth?
  A. What is the relation between the earth and the sun and moon?
  B. How do the sun's rays help us to see most things?
  C. How do we get the colors of the rainbow?

Problem XIII. How does the earth's surface change?
  A. What does freezing and thawing do to rocks and soil?
  B. How does snow change rocks and soil?
  C. How does running water change rocks and soil?

Problem XIV. How should one handle tools?
  A. How can one prevent injury to himself or others in the school workshop?

Problem XV. How does light help us to see?
  A. What makes colors in the sky?

Problem XVI. How do plants use stored food in spring?
  A. How do seeds use stored food in spring?
  B. How do trees use stored food in spring?
  C. From what other plants do we obtain sugar?
  D. How do many weeds store food?
  E. How can we tell the difference between hard and soft maples?
  F. How can we recognize other trees?

Problem XVII. How can we know the woodpecker family?
  A. How can we recognize members of the woodpecker family?
  B. What are the habits of flickers as members of the woodpecker family?

Problem XVIII. How do we get fresh air into buildings?
  A. How can a room be ventilated?

Problem XIX. How do magnetism and electricity affect our lives?
  A. How does a compass work?
  B. How can magnetic force be shown?
  C. How can we obtain electricity?

Problem XX. How can we have a good garden?
  A. How can we prepare a vegetable garden?
  B. How shall we care for a vegetable garden?

Problem XXI. How are animals classified?
  A. How can we tell the different classes of animals?

# ACTIVITIES USEFUL IN SOLVING THE PROBLEMS IN *THE HOW AND WHY CLUB*

## PROBLEM I. HOW DO AIRPLANES FUNCTION AS A PART OF TRANSPORTATION? (Pages 5–20)

*Science Concepts*:

1. Airplanes land on special landing fields.
2. Airports have every possible safety regulation and device.
3. Pilots must obey signals and regulations for their own and their passengers' safety.
4. Passengers, visitors, and the ground crew must also obey safety regulations. Weather is one of the most important factors in flying.
5. A pilot must know the direction and force of the wind before landing. He must also know which runway he is to use.
6. Red and green lights are used to signal when a plane is to land.
7. The important parts of an airplane are: propeller, engine, landing gear, fuselage, wings, ailerons, elevator, rudder, nose, and stick.

*Suggested Activities*:

In the primary grade books of this series, the children learned the basic concepts for understanding this story. If the group has not had this foundation, the teacher should give them some of the simple experiences with air that are suggested in the primary manuals.

This story may be used at the beginning of the school year or at a time when questions make it useful.

Children are naturally interested in airplanes and at this age are often starting to make model planes. Their interest can be utilized

in motivating the initiation and solving of problems. As indicated in front of this manual, one of our major objectives in teaching science to children is to develop the ability to recognize and solve problems of everyday life. Any good questions may be used for this purpose. In the primary grades, the children solved small problems, learning some of the necessary skills, such as gathering data, recording it, and drawing conclusions from their data. They did not, however, know that they were learning a scientific method of procedure. In the fourth grade, children may be taught to recognize a good problem, to select one from the many questions they may have, and consciously recognize the steps in its solution. Questions such as "What makes an airplane fly?" are good problems to use for teaching these steps. The first step in solving a problem is discussion to be sure that the problem is clearly defined in the children's minds. We write the question on the board. The children give their ideas. At a point where all reasonable ideas have been given, the teacher may say, "All of these ideas may be good ones, but I am not sure. It seems to me that we need to do something besides talk. What do you think it is?" Or, "Do you think we are actually answering our question? You don't agree in your ideas." Or, "What are we going to have to know before we can begin to answer our question?" What she says to direct their thinking will depend upon the children's backgrounds and the material available for study.

Some sub-problems may have to be solved before the large one is attacked. So, following the defining of the problem will come the analysis or breaking it down into its parts. Fourth-graders won't realize this, perhaps, but a question like the last one in the preceding paragraph may bring such suggestions as, "Why does anything float in air?" "Why does an airplane go up when it is heavier than air?"

The next step in problem solving is the forming of an hypothesis. With fourth-graders we call these possible answers. During the discussion the children may have suggested partial answers that are reasonable. These should be listed even though the teacher knows that the answers are neither complete nor correct. An hypothesis is based on some fact, so these possible answers should be based on facts so far as the children know them. If they have

*no* facts or information, they may need to explore a bit before setting up possible answers.

They may do some simple experiments with air to try to find out what makes things float in air. They may experiment with balloons, soap bubbles, kites, and paper gliders. They will discover that all of these come down unless filled with a gas lighter than air. They stay up only so long as air currents are going up. Also, the difference in the way they float in still air and moving air will be observed.

Following the setting up of possible answers, the next step is gathering data to apply to these possible answers to see if any of them are right. The children may label this portion "What we do (or did)," depending on when they write it down. There are many activities which will help in developing the concepts needed. If possible, the children should visit an airport and watch planes landing and taking off. As they watch, discuss the various visible operations, such as the removing of the blocks, closing of doors, starting the propeller and so on. Notice any movements of the rudder and ailerons.

In the schoolroom, experiment with paper planes, bending the wings at different angles to observe the effect on the falling planes.

Watch birds flying, noticing the shapes of their wings and bodies. Compare with the human body as to advantages for flight. Put both hands together like a wedge and push against the air as a bird's body would cut the air. Then with the hands together side by side, push as our bodies would be pushing if we tried to fly. Discuss the advantages of a plane's shape.

Construct kites and gliders of various shapes to discover which is best. Discuss the shapes of planes used for different purposes.

All these activities should lead to the concept that air must support things that float in the air. Since children know that all airplanes are heavier than air, they will have to perform some experiments demonstrating how less pressure is developed above a plane than beneath it. A very simple activity is to let each child hold the end of a streamer of paper just under the lips and blow across its surface. The streamer will rise and should float straight. This is the principle of lift on the wings and body of a plane. As you blow

the upper surface of the streamer, the stream of air carries air with it and reduces the pressure.

The fan of a vacuum cleaner demonstrates what happens as the propellers spin. They reduce the pressure at the front of the plane and as the air flows over the top of the plane it reduces the pressure above the plane. The pressure below does the rest.

## PROBLEM II. HOW DO PLANTS STORE FOOD? (Pages 21–35)

This problem may arise in the autumn as suggested, in the winter when potatoes and onions are sprouting in bags in warm kitchens, or in the spring when the plants are using their stored food. It may grow out of many normal experiences of children—their interest in the foods they eat and their source, or their interest in branches they bring into the room to sprout in water, in late winter.

The advertising of Vitamin $B_1$ and its effect on root growth has awakened in children an unusual interest in plants. They are asking questions about chemical gardening. These may easily lead to a much more intensive problem on plant foods than we have thought possible in the fourth grade.

During work on the problem, the children should visit a vegetable cellar, a grocery store, a market, or some other place where many kinds of fruits and vegetables are kept. They should be encouraged to bring examples from home.

*Science Concepts:*

1. Plants store food in roots, stems, leaves, seeds, and flowers.
2. Man makes use of the food stored by plants.
   - *a.* Such vegetables as cabbage, lettuce, and spinach are leaves.
   - *b.* Carrots, beets, turnips, parsnips, and sweet potatoes are roots.
   - *c.* Corn, wheat, beans, and nuts are seeds.
   - *d.* A bunch of celery is a cluster of leaves with thickened leafstalks.
   - *e.* Irish potatoes are underground stems or tubers.

*f.* Onions are bulbs. Bulbs are underground buds with fleshy leaves.

*g.* Some plants store one kind of food; other plants may store a different kind.

*h.* Starch, sugar, protein, and fat are the kinds of foods usually stored.

*i.* We eat some vegetables because they contain minerals.

3. We can make tests to find out what kinds of foods plants store.

   *a.* A simple test for fat is the grease spot test. Foods containing fat make a grease spot when crushed on paper.

   *b.* Butter and nuts have fat in them.

   *c.* Iodine is used to test starch. It turns dark blue when put on starch.

   *d.* Irish potatoes contain much starch; sweet potatoes not so much; carrots very little.

   *e.* Trees store starch in their roots, stems, and at the base of buds.

   *f.* Foods that have much sugar in them taste sweet.

4. Vegetables like cabbage, potatoes, and onions may sprout in the house if they are in a warm place. The stored food and water in them makes this possible.

*Suggested Activities:*

A TRIP TO ANDY BAKER'S CELLAR (Pages 21–28)

After taking a trip to see different kinds of vegetables and fruits, the children should discuss what they have seen. Let them suggest different things they eat at home and try to tell from what part of the plant each came. If the children do not know the parts of a plant, the teacher should use some common plant to show the roots, stems, leaves, and flowers. A geranium is a good house plant to use.

Many people mistakenly think an Irish potato is a root because it grows underground. Clarify this belief with children by having them first compare the root and stem of the plant they have observed. They will see that a stem has buds on it, while a root has

rootlets on it. They will see that a carrot and sweet potato have rootlets along them, and just one stem end, while the Irish potato has many buds and no rootlets. If they put carrots, sweet potatoes, parsnips, or turnips into water, the rootlets will soon grow and leaves sprout from the stem end. The Irish potato will sprout but stems and leaves will come from all the eyes. Roots will not grow from the eyes. If the potato is cut, roots grow from the cut end.

To make a cabbage sprout in the spring, it should be set on a shelf away from the sun. Usually enough water is stored in the cabbage to cause it to sprout. If put in water, just enough to cover the stem end should be used, or the cabbage will decay. Sometimes a number of sprouts will grow from the base of the cabbage.

The children should do all of the experiments suggested by the story. To show how the food is used by plants, the activities suggested above should be carried out. It is interesting to put some Vitamin $B_1$ in some of the jars of water to see the difference in root growth with and without it.

### THE FIRST EXPERIMENTS (Pages 29–35)

While the scientist might not dignify these simple tests with the name of experiments, to children they are experiments. If carried out carefully in the process of solving problems, children will begin to learn the elements of scientific method.

If the teacher wishes to demonstrate the protein test, she will need some nitric acid and ammonia. She will also need a pipette (dropper) to use with the acid. Nitric acid *must* be handled with care as it will burn. Drop a few drops on food such as egg white. Protein will turn yellow. Then drop a few drops of ammonia, and the color will change to deep orange.

A chemical fat test is too difficult for children, but since foods containing very much fat show a grease spot if crushed on paper, presence of fat in foods is easy to demonstrate. While to a teacher it might be obvious that celery doesn't contain fat, children need to prove it. They should be allowed to test any food they are interested in so long as learning is taking place.

Since the iodine test for starch is very simple and quite exciting to fourth-graders, it is a good one to use to introduce children to experimental technique.

The chapter in the pupil's book gives the test in detail. If a solution of iodine in alcohol is used, the food should be moistened with water before putting the iodine on it. Hard foods like corn or beans may have to be soaked in water and broken open before the iodine will penetrate enough to react. Twigs should be split with a sharp knife or razor blade. They, too, will vary in the amount of starch present. In tree stems there is a layer of cells which store starch around the vascular tissue.

There is likely to be variation in the amounts of starch in different carrots, beans, and other things tested. Part of the value of this type of experiment is to help children develop scientific attitudes. One of these attitudes is to base conclusions upon sufficient evidence. The children will also discover that variety is one of the laws of living things.

The materials needed for these experiments are:

| | | | |
|---|---|---|---|
| saucers or test tubes | iodine | butter or other fats | potatoes |
| | starch | paper | carrots |
| | sugar | | turnips |
| | salt | | beets |
| | | | other vegetables |

Although we commonly refer to the things we eat as foods, technically the foods are starch, sugar, protein, fats, minerals, and vitamins. Only the portions of fruits, vegetables, and so on, that actually help make new tissue, energy, or protect the body, are foods.

## PROBLEM III. HOW DO WE USE CHEMICALS EVERY DAY? (Pages 36–43)

This problem may arise in a number of ways. Someone may bring a chemistry set to school with the announcement that he can do some stunts with it. Or an accident in the workshop may result in a hole being eaten in a sweater by acid. Or the children may be curious about the changes which took place in their food tests. The purpose is not to teach about the chemicals found in a laboratory, but to answer children's questions about the chemical changes constantly going on around them. No elaborate equipment is necessary as only common substances are used.

*Science Concepts*:

1. We use many chemical substances every day.
2. A chemical change is one that can't be changed back.
3. All substances have certain properties by which we know them.
4. Litmus paper is the test for an acid.
5. Many common foods are acid.

*Suggested Activities*:

All of the activities suggested in the story are easily done in any classroom. Litmus paper may be bought at a drug store. The tests for acids and alkaline substances are interesting enough to children for them to spend as much time as seems worth while. If they test a number of fruits, they will discover that most of them are acid. They will also find that many foods which do not taste sour are slightly acid. For instance, milk, even though it has been kept cold and tastes sweet, may turn blue litmus to pink. The lactic-acid bacteria in milk work fast.

Although the words alkali or base are not used in the text, the children soon realize that some substances counteract an acid and neutralize it. The teacher may teach as many of these words as seems wise. For example, if a child is trying to find a word to express what is happening to vinegar and soda, it is much better for him to learn *react, counteract,* or *neutralize* when it is needed than to say "it kills or fights" the acid.

Pink litmus paper turns blue when it is put into an alkali. Let the children dissolve a little soda in water and put both pink and blue litmus paper into the solution. They may say that soda is "opposite" to acid. Then they may put a small amount of vinegar into a tumbler. Fasten a piece of blue litmus on the inside of the glass so that it touches the vinegar and turns pink. Then begin to pour the soda water into the vinegar, a little at a time, stirring after each addition. Watch what happens to the color of the paper. When the acid is neutralized the color will be violet or lavender. The concept gained should be "an alkali will neutralize an acid." If a bottle of soda water had been available in the workshop when acid was spilled on the sweater, the acid might have been neu-

tralized and the sweater saved. This would be a practical application of something learned in science.

Another activity demonstrating chemical change is to try putting different colored materials in the sun to see the effect of sunlight on dyes. By placing stencils, with patterns cut out, over the materials, a design will be printed on the paper or cloth. Blue prints may also be made to show how man makes use of this principle.

Our whole purpose in teaching children this material is to help them interpret the phenomena about which they are curious and to give them concepts that apply to their daily lives.

## PROBLEM IV. HOW DO SOME ANIMALS USE THE FOOD STORED BY PLANTS? (Pages 44–72)

The sub-problems that are developed here are given in the outline on p. 62 of this manual. The material is intended to teach those characteristics of a common class of mammals, rodents, which have made it possible for them to survive, also to show the dependence of animals, including man, upon plants.

*Science Concepts*:

1. Beavers are mammals with remarkable modifications and habits that make it possible for them to live as they do.
   *a.* Beavers have very strong chisel-like incisor teeth which they use in cutting trees.
   *b.* Beavers build dams and lodges with the logs they cut.
   *c.* The dams make ponds in which the beavers build their lodges.
   *d.* The food of beavers is mostly roots and stems of plants, especially the bark of young willows, poplars, and aspens. Beavers store food which is used during the winter.
   *e.* Beavers have flat tails covered with flat scales. They use their tails as rudders and as warning signals.
   *f.* Beavers have webbed feet that help them to swim. Their thick fur protects their bodies from getting wet and cold.
   *g.* Beavers live in colonies, a family in each lodge.
2. Muskrats are rodents which live near water. They haven't so many adaptations for life in the water as beavers have.

## HOW BEAVERS LIVE (Pages 44–59)

Because of their habits, beavers have captured the imagination of fiction writers, and, as a result, many misconceptions concerning beavers have arisen. In presenting this problem, teachers should be careful to check the accuracy of any stories the children read or tell. The truth is interesting enough without embellishment.

If possible, children should watch live beavers. They may be found in their native habitats by the cut trees, dams, and lodges. The teacher should locate such places and take the children to see the beavers' work. Beavers come out to feed in the late afternoon, and in many places are not afraid of human beings. By sitting quietly near their lodges, you may be fortunate enough to see them.

Many zoos have live beavers which city children may observe. If you are teaching where it is impossible to see live beavers, at least try to have a beaver-gnawed log, a skull, and perhaps a stuffed beaver. Any one of these makes a good introduction to the problem. A beaver-gnawed log and the question, "How do you suppose this log was made to look like this?" will usually start a lively discussion.

In many regions where there are no beavers, muskrats are common. While not of the same family as beavers, muskrats are rodents, and some of their habits are similar to those of beavers.

There are excellent government bulletins on beavers and muskrats which will help the teacher with her own information.

The fallacy that beavers have human intelligence should be avoided. Their behavior is inherited and instinctive. For example, all of their trees are *not* cut to fall toward the river; many fall in the opposite direction, are caught by other trees, and never reach the ground. In places where most of the trees seem to have fallen toward the water, investigation may show that they were all on ground sloping toward the water.

In this story, Jack illustrates some common ideas about beavers when he says, "Beavers are smart animals," and "Beavers go to a lot of trouble to store their food." A teacher may use these places to teach correct scientific attitudes. She may say, "On page 51 is a statement with which I don't believe a scientist would agree. Can you find it?" On page 54 is a statement that may be misconstrued —"The new dam will probably be the home of the young beavers

which are just mating." This does not mean that the beavers live in the dam, but that the dam makes the pond which will be the home of the beavers. The correct name for young beavers is "kits." Children should learn the correct names for the young of all animals and not call them "babies."

### OTHER GNAWING ANIMALS (Pages 60–67)

*Science Concepts*:

1. All rodents have chisel-like incisor teeth that grow as they are worn down by gnawing. Because the enamel on the front of the incisors is harder than on the back, the gnawing teeth are self-sharpened.
2. Beavers, squirrels, muskrats, chipmunks, and rabbits are rodents.
3. Cows and sheep have teeth fitted for grinding food. They are plant eaters.
4. Dogs and cats have pointed teeth fitted for tearing. They are meat eaters.

One purpose of this story is to begin to give the children a basis for classification of mammals. In the primary books they learned that mammals feed their young on milk, have fur, and usually are born alive.

Mammalia is a class of vertebrates. The class Mammalia is further divided into orders. Three of the common orders of Mammalia are: Rodentia (gnawers), Carnivora (meat eaters), Herbivora (plant eaters). Of course, the children are not to be taught these technical terms. Identification and classification are not our major objectives in teaching science to children. However, "What is it?" is usually the first question children ask when they see an animal. If they know the characteristics of these groups of animals, it helps them to answer their own questions. Children often come to class and say, "I saw an animal. I think it was a rodent because it was gnawing a twig." They then go on to describe its appearance. Or, "I found an insect. I know it was an insect because it had six legs." Or, "This must be related to spiders, for it has eight legs." They get a great deal of satisfaction from their ability to help answer their questions.

*Suggested Activities*:

In teaching these concepts, the children should observe some live rodents. Rabbits are not as typical as squirrels. Rabbits' incisors do not have as hard a coat of enamel as squirrels'. The extra pair of incisors, which have disappeared in most rodents, are rudimentary in rabbits. These rudimentary teeth can be seen just back of the two well-developed incisors.

White rats are easily obtained in places where children can't observe chipmunks and squirrels. Rats and mice are typical rodents; so are porcupines, prairie dogs, ground squirrels, woodchucks, and guinea pigs. Thus it is easy for any teacher to have live animals to use in this problem. A young porcupine, found on a college campus, made an interesting pet. From it, the children learned that porcupines do *not* throw their quills. This helped develop the scientific attitude of basing conclusions on sufficient evidence.

The children will probably notice the orange or red-brown enamel on the front of the incisor teeth. They may think it is stain. A good question then would be, "Why would it be just on the front and not on the back of the teeth?"

If they notice the space between the incisors and back teeth due to the absence of one pair of incisors and the canine teeth, the teacher might ask, "How would this help the squirrel?" Be careful not to let the children think the teeth grew that way *in order* to help the animal get its food. The principle to be developed here is: *Animals as they are today have survived because of the modifications they possessed. These modifications made it possible for them to meet changing conditions.*

If the teacher can obtain skulls of some of these animals, she will find that the children are intensely interested in them. By comparing these skulls with their own teeth and jaws, they will learn much about the human skull.

For teachers who haven't had experience teaching science to children, a few sample lessons may be helpful. These lessons are taken from actual units as taught. The statements of the children are given to show how the teacher may direct the solution of problems and help in the development of scientific attitudes by using children's contributions.

LESSON 1. Problem-setting type.

*Introduction*: By means of riddles.

Teacher: "It is a little animal covered with fur. It has four sharp incisor teeth. It burrows into the ground and makes a winter home where it stores nuts and berries. What is it?"

Child: "Chipmunk."

Teacher: "It is a rodent but has no tail. What is it?"

Child: "Guinea pig."

Teacher: "There is another rodent we haven't studied. Its four large incisor teeth are reddish brown on the front. It has thick golden-brown fur and a flat tail. It gnaws down trees."

Child: "A beaver."

Child: "I know how it balances itself when it cuts trees."

Teacher: "How?"

Child: "With its tail."

Teacher: "What else do you know about beavers?" (She writes on the board as the children tell what they know.)

Child: "It has a tail which it uses as a rudder. It slaps the water with it and carries mud on it."

Teacher: "Are you sure it carries mud on its tail?"

Child: "I know it carries mud on its tail because it has to use its feet to swim with."

Teacher: "You *know*? How?"

Child: "I read it in a book."

Teacher: "What kind?"

Child: "A story book."

Teacher: "Can we always depend on a story book to be true?"

Child: "No."

Teacher: "Then what had you better say?" (Teaching the attitude of not believing everything read or heard without sufficient evidence.)

Child: "I *think*."

Child: "I saw some pictures of beavers with mud on their tails."

Teacher: "Shall we put that down as one of the things we need to make sure about?" (Children agree.)

Child: "It lives in water."

Child: "It cuts trees so they fall into the water. Then it pushes them with its nose."

Teacher: "I wonder if that is true." (Same attitude as above. Teaches child not to jump to conclusions.)

Child: "Put it on the board to find out."

Teacher writes this list of things the children want to find out:

1. Does the beaver slap water with its tail?
2. Does it carry mud on its tail?
3. Does it cut trees so they fall into the water?
4. Does the beaver have molar teeth?
5. Does it have scales on its tail?
6. Are its feet like other rodents' feet?
7. What kind of home has a beaver?
8. How does it defend itself?

These questions were organized under these problems:

1. How does a beaver's tail help it?
2. How do beavers cut their trees?
3. How do beavers make their homes?
4. How are beavers protected?

LESSON 2. Problem-solving type.

*Problem*: How does a beaver's tail help it?

*Analysis*: The children looked at a stuffed beaver and discussed the size and shape of the tail.

*Hypotheses* (*Possible answers*):

1. Perhaps the tail is used as a rudder.
2. Perhaps the tail is used as a prop.
3. Perhaps the tail is used to carry mud and pat it down.

*Testing the hypotheses*:

Gathering data: The children read in authoritative books. They looked for actual photographs of beavers. They asked people who had watched beavers.

Results: Nowhere did they find an authoritative statement that beavers carry mud on their tails. They found that beavers do use their tails as props and rudders.

*Conclusions*:

The children decided that a beaver's tail helps it to swim and to stand on its hind legs. They also decided that they couldn't believe everything they read.

LESSON 3. Problem-solving type.

*Problem*: How do beavers cut and use trees?

*Analysis*: The teacher brought two pieces of beaver-cut wood to class. One was a stump, the other a branch from which the bark had been gnawed. She said:

"Last year I visited a river near here and found these. I wonder what stories they might tell if they could talk."

Child: "That is the work of a beaver."

Teacher: "How do you know?" (Developing the scientific attitude of not jumping to conclusions.)

Child 1: "He's gnawed it and cut it down."

Child 2: "One is the trunk and the other is a branch."

Child 3: "The beaver cut as close to the ground as it could with the trunk. One is shorter and fatter."

Teacher: "There is something else."

Child: "The beavers have taken all the bark off one."

Teacher: "Which one?"

Child: "The branch."

Teacher: "Why did they do that?"

Child: "To eat it."

Teacher: "Yes. What would they do with the sticks?"

*Hypotheses*:

1. "I think they'd use the trunk to make a house and the branches for a dam."
2. "They could use long ones with the bark off for a dam."
3. "They'd use the top parts of the tree because they would bend easier when you put mud on them and wouldn't crack."

*Solution*:

Teacher: "These are good ideas. Where was this large one in the beginning and what happened to it?"

Child 1: "The beaver cut it and took it down the river."

Child 2: "I think it ate on the longest piece and built a dam with the short one."

Child 3: "The longest, thinnest piece is a young tree."

Teacher: "What makes you think so?"

Child 3: "The branch would be longer if it were that big around."

Child 4: "The young tree would be tender. The old branches on a tree would be stiff and the beaver couldn't eat them."

Child 5: "He was going to use the trunk for the dam and the stick for the house because the tree is cut so that it will fall into the water."

Teacher: "I wonder if that is true. Let us imagine that we are in a forest where a beaver is working. There is a stream near the tree the beaver is cutting." (She draws a diagram of a river bank as she talks and shows the way a tree is cut.)

Teacher: "If a beaver is gnawing a tree what happens to the top part?"

Child 1: "Maybe he cuts more on one side than the other."

Child 2: "He goes all around the tree."

Teacher: "Do you mean that he works around a tree just as a squirrel gnaws around a nut?" (Helping the child to visualize the beaver's activity by comparing it with a familiar observation.)

Child 3: "All the pictures show that he works around the tree."

Teacher: "Shall we try to reason it out from what we know?"

Child 4: "If he cut all around, he wouldn't know which way it would fall."

Teacher: "Which way would this tree fall?" (Pointing to diagram.)

Child 1: "If he is gnawing on this side, it would fall on the other side."

Child 2: "He'd have more sense than to stand on the side where the tree was going to fall."

Child 3: "When he cuts there, it would fall that way because it doesn't have anything to hold it up."

Child 4: "The tree would have to fall near the water. He couldn't carry it."

Teacher: "Do you think beavers *want* the trees to fall a certain way? Can beavers think the way we do? How can we really find out?" (Bringing out the idea that beavers' behavior is instinctive.)

Child 1: "Get a small dead tree and chop it down. Even a limb would do. Or watch someone cut a tree."

Teacher: "A good suggestion. What is another way?" (Encouraging the child even though his suggestion isn't practical, while stimulating further thinking.)

Child 1: "Read some more."

Child 2: "Look at pictures."

The children looked at many pictures of beavers cutting trees and of fallen trees. They read farther in their story of beavers. They performed an experiment with a stick that had a wedge cut in it. When the wedge was removed the unsupported part fell.

*Conclusions*:

Teacher: "What have we found out?"

Child 1: "Beavers use trees for the bark they eat."

Child 2: "Beavers really don't know which way trees will fall."

Child 3: "We found out that sometimes a forest has trees that have fallen against other trees and been wasted because the beavers couldn't reach them."

Child 4: "Beavers use trees to make dams and lodges."

### DIFFERENT KINDS OF TEETH (Pages 68–71)

*Science Concepts*:

1. Human teeth are similar in structure to the teeth of other mammals.
2. The permanent teeth of children usually replace the milk teeth or deciduous teeth in this order:

   The first permanent molars erupt between the ages of 5 and 7.

   The four permanent central incisors appear shortly after, and the four permanent lateral incisors between 7 and 9.

   The first and second permanent bicuspids usually erupt between 10 and 12.

The permanent cuspids, four in number, between 9 and 12.
The permanent second molars, between 11 and 13.

3. A child at fourteen should have eight incisors, four canine teeth, and sixteen molars.
4. A child needs the right kind of food to keep his teeth in good condition. His teeth also need proper care.

*Suggested Activities*:

There are some excellent charts that will aid in the teaching of the concepts in this story. See the bibliography.

Dentists do not agree on the best way to care for teeth or what it is that makes good teeth. Some say it is heredity, some, that the food eaten during tooth formation makes good teeth, and others put a good deal of faith in cleaning. Some dentists claim that the acid due to too many carbohydrates in the diet is responsible. Recent studies seem to show a relationship between fluorine in drinking water and good teeth. At any rate we still clean our teeth, if only for the comfort it gives us. We know that an acid mouth is not healthful. We also know that a balanced diet with plenty of vitamins and minerals helps the general health of growing children.

A simple test that the children enjoy is the litmus-paper test. If they have done the experiments suggested in the chapter on chemicals, the children may test the reactions of their own mouths. A healthy mouth is neutral, slightly alkaline, or only slightly acid.

The story suggests using dental floss and a soda-salt solution for cleaning the teeth. The teacher should either show the children how to use the floss or ask them the proper way; also, how to make the salt-and-soda solution. Some dentists claim that dry salt rubbed on the teeth has an abrasive effect that is harmful.

One fourth grade wanted to experiment to find out what bits of food left between the teeth would do to the teeth. Some of the suggestions they had for these activities were: (1) to put some cooked oatmeal in a test tube with a tooth (usually available in a fourth grade) and put it in a warm place until it spoiled; (2) put a tooth into some acid to see if acid affected it. One child objected to number 1 as being invalid. He said that the oatmeal would be mixed with saliva in your mouth and that that might make a dif-

ference in the results. This showed good thinking and the habit of weighing evidence with respect to its soundness. He was allowed to chew some oatmeal and set up another test tube with the chewed oatmeal. His remark, "This *might* not prove anything yet for it isn't in your mouth," demonstrated an unusually highly developed attitude for a nine-year-old.

At the end of a week the oatmeal was very much spoiled in both test tubes. The teeth showed no change. But the tooth in HCl had become soft. The children said, "Maybe there is acid in the oatmeal but it isn't strong enough to eat the tooth. Let's test it with blue litmus paper." The test showed that the oatmeal had become very acid. The children discussed their results, checked with articles on tooth decay from science magazines and decided that over a long period of time, food left between the teeth *might* produce enough acid to cause tooth decay. Therefore, food particles should be removed.

This actual teaching experience demonstrates how teachers may allow children to set up problems not mentioned in a text or outline, to suggest experiments no adult ever thought of, and carry them out. Then they should check with an authority before drawing conclusions. In some cases they may have to say in conclusion, "These things happened—we *think* so-and-so may be true. We are not sure." All questions can't be settled, but there should be some summarizing statements to give the children a feeling of accomplishment—that on their level of understanding and with the material they have been able to use, there has been progress.

## PROBLEM V. HOW DO SPIDERS WORK?
(Pages 73–87)

*Science Concepts*:

1. Spiders are invertebrates having interesting habits and modifications that fit them to the life they live.
   *a.* Spiders have spinnerets on their abdomens which they use in spinning silk.
   *b.* Some spiders make webs in which they catch their food.
   *c.* Spiders are helpful because they kill insects.

*d.* The Black Widow spider is the only spider in the United States that is poisonous to man.

*e.* Spiders are not insects. They have eight legs, while insects have six, and only two body sections instead of three.

*f.* Spiders reproduce by laying eggs that hatch into little spiders. The eggs are usually enclosed in sacs of silk made by the female spider.

*g.* There are many interesting spiders, such as Golden Garden, Crab, and Trap Door spiders.

The purpose of this problem is to add to the biological principle stated in Problem IV; also to give the children more understanding of the classification of different animals and their place in the maze of life, to answer questions, and to develop appreciation of the importance of spiders to man.

Spiders belong to the great group or zoölogical phylum, Arthropoda. To this phylum belong also the insects, crustaceans, millipedes, and centipedes. The word, *Arthropoda,* means jointed feet. All the animals belonging to this group have jointed legs and segmented bodies. They are more highly developed than the other invertebrates. Invertebrates are those animals without backbones.

There are four classes of Arthropoda: Crustacea, Insecta, Arachnida, and Myriapoda. Spiders belong to the Arachnida; insects to Insecta. Here again, children should not be made to learn these technical terms, but the teacher needs to know the scheme of classification to help children answer their questions. The references at the end of this Manual will give her more information.

One of the important objectives that may be accomplished by this study is the developing of an understanding of cause-and-effect relationships. People often fear spiders, with no good reason. Children should be helped to overcome these unreasoning fears, or, if they don't have them, be given a basis of knowledge that will prevent such fears.

*Suggested Activities*:

The teacher may have to overcome her own fear of spiders. One of the best ways to do this is to keep live spiders in a terrarium and

feed them live insects. In the autumn, many spiders are making their egg cases. The orb weavers make very beautiful webs. If brought into the classroom and put in large enough cages or terraria, they may spin webs. You may be fortunate enough to get a female spider that will make her egg case while the children watch. The eggs will hatch during the autumn or winter, and the young spiderlings live inside the egg sac until late winter or early spring. Being cannibals, the stronger ones feed upon the weaker and grow strong enough to bite through the case. Some day the children will be much excited to see dozens of tiny spiderlings swarming out of the case and spinning little threads on which to glide off to new homes. If they can get out of the terrarium, they will float in the slightest breeze to a perch on a window sill, curtain, or any convenient landing spot. If caught, they should be released out-of-doors to start a new generation of insect eaters.

The children may observe the spiders closely through the glass sides of the terrarium. Glass jars are good containers in which to observe individual spiders. Watch the way they spin, run along a thread, capture their prey and suck the juice from the insects' bodies. Hand lenses will help the children observe more closely.

If you live in a region where Black Widow spiders are common, it is very important that the children learn to recognize them and their habits. Black Widow poison, volume for volume, is more virulent than rattlesnake venom. Fortunately, there isn't much of it, and it seldom kills an adult. Fortunately also, spiders are shy and bite only when cornered.

Black Widows are frequently found in basements spinning webs in corners. Children often capture them in glass jars and bring them to school. They should be taught how to capture spiders without danger to themselves. A jar under the spider with a lid clamped down over it quickly eliminates all danger. There is no danger when you see the spider first, for it can't jump on you or fly. It has to run or float on a thread, and it will run away from, not toward, a human being.

Only the female Black Widow is harmful, and she is like the picture on page 80, that size or smaller. Remember the red hourglass-shaped spot is on the *under* side of the abdomen, and that she is like a shiny black button.

If you have a microscope available, kill a spider in a drop of kerosene and pull the fangs out with a pair of tweezers. Mount the fangs on a slide and examine under the low power of the microscope. Even a reading glass will help the children see the fangs. All spiders have fangs with which to kill their prey, but while a spider bite may be painful, only the Black Widow's is serious to man. Of course, any bite may become infected just as a pin-prick may. Children should be cautioned not to handle any animal roughly or unnecessarily.

By feeding flies to a spider and estimating how many flies that spider and its offspring will eat, children are impressed with the economic importance of spiders.

The changing color of the spider on page 84 is another example of adaptation. No one knows what makes it change color. It may be the effect of light rays on specialized cells in the spider's epidermis. Those spiders of that family which through the ages possessed the characteristic, survived and passed the characteristic on to their descendants.

In different parts of the United States, interesting relatives of spiders may be found. Some of them live in the ground and have modified front legs that resemble the pincers of a crayfish. In the South and West, there are several varieties of scorpions, Arachnida, with vicious stingers on the ends of their tails. Wood ticks, dog ticks, and mites are also members of this class. The teacher should try to familiarize herself with the common Arachnida of her locality but if a child brings in an eight-legged creature unknown to her, she at least has a clue as to where to look it up.

## PROBLEM VI. HOW DO PLANTS AND ANIMALS DEPEND ON EACH OTHER? (Pages 89–107)

*Science Concepts*:

1. Animals could not live without plants.
2. Many plants are dependent on animals for their survival.
3. The life in a body of water is interdependent.
4. When plants, animals, and the physical factors of their environment have reached an equilibrium, we speak of it as the balance of nature.

5. Man in the past has done much to upset the balance of nature. He should try to repair the damage he has done.

### PLANTS DEPEND ON ANIMALS (Pages 89–93)

The purpose of this story is to introduce the interrelationship between flowers and bees. A more intensive section on bees will be found in the fifth-grade book. Bees should be studied here only as they contribute to the major problem.

This problem may be introduced in many ways. If the children have just been studying spiders and their relation to insects, they may have asked about bees. In one case the question arose as to what would happen if you put a spider and a bee into the same jar. The children tried it. The spider killed the bee. Then a child said, "That isn't proof. They were shut up. How do you know that would happen outdoors?" Such a good scientific attitude demanded proof and watching bees in the garden.

The teacher might catch a worker bee with pollen on its legs, in a jar, and let the children examine it. Questions like "How did those yellow balls get there?" will stimulate discussion and lead to questions.

*Suggested Activities*:

Actual observation of bees at work is the ideal activity. If you have an available garden, weedy lot, orchard in bloom, or any other place where bees gather, make the most of it. Wild bees may be observed in fields and meadows. A discussion before the trip of what to look for, or a question such as "How many flowers do you suppose one bee will visit while we're there?" or "I wonder how many kinds of flowers one bee will visit?" or "How do the bees get the nectar or pollen?" will stimulate careful observation. Incidentally, the children may see other insects at work. It's a rare garden that doesn't have a crop of aphids (plant lice), the ants' cows. Children will come running with, "What are all of those black bugs on the nasturtiums?" or "There are a whole lot of ants going up the cosmos stems." Remembering the purpose of this problem, these plant and insect relationships are just as desirable to observe as those of the bees. The stories are too closely interwoven to separate.

Look also for ladybugs (ladybird beetles) and their larvae, on plants infested with plant lice. The beetles feed on the eggs, larvae, and adults of many insects, some of which are aphids, scale insects, and potato beetles. An interesting activity is to put some ladybird beetles into a jar with a potato leaf covered with the orange-colored potato-beetle eggs. Then watch the feast. A hand lens will help.

In the autumn many insects are going into hibernation. Such insects as the box-elder bugs are finding shelter in buildings. In the spring the bugs will go to the box-elder trees to start a new generation.

Many tiny insects live in the leaves of different kinds of plants. Some of them tunnel into the tissue of a leaf between the upper and lower epidermis, making queer-shaped streaks and spots on the leaf. These insects are called leaf miners. When the leaves fall from the trees, you can find many types of miners. Other insects are the leaf curlers, leaf stitchers, and leaf rollers, as Dr. Needham calls them. The galls and stem and root borers are other examples of plant and insect relationships. To find the borers, pull up weeds with woody stems and split the stems and roots. One plant, like a goldenrod, may have galls, stem borers, and root borers living in the same house, so to speak. These are not mutually beneficial, as is the bee-flower partnership, but they illustrate the maze of relationships between plants and animals and lead into the next story.

### ANIMALS DEPEND ON PLANTS (Pages 94–105)

After the trips just suggested, a chart might be made on the board with the headings: Animals that help plants; Plants that help animals. On these charts the children could list all the animals they have observed or know about. This will help to impress the fact that insects and spiders are animals. A question "Do you know of other animals that depend on plants?" or "Can you think of an animal that could live without plants?" should start a discussion. After reading the story, the children might make stories of their own similar to Martha Lou's and Randy's.

One fallacy believed by many adults may be taught in this story if the teacher doesn't anticipate it. Because in a balanced aquarium plants are necessary to provide oxygen for the fish, many peo-

ple think that the breathing of plants and animals is opposite. This is not true. Plants use oxygen in respiration and release carbon dioxide just as animals do. But green plants in their food making use more carbon dioxide than they release in respiration and release oxygen as a waste product. Water plants are able to use the oxygen in water for respiration. Hence they help to maintain a balance.

Every schoolroom should have a balanced aquarium in it. Elsewhere in this manual, directions for making one will be found. An experiment to demonstrate the balance is easily carried out by having one fish in a bowl of water with just sand in the bottom and another exactly like it with growing water plants. The fish without the plants will begin coming to the surface for air very soon unless the water is changed. An aquarium need not be an elaborate one. In this instance, there is more value to be derived by having each child make an individual aquarium in a jar. Wide-mouthed fruit jars may be used and common pond plants and animals put into them. Each one may have different animals. One may have a snail and water insect. Another may have a small crayfish and a snail. A tadpole and some mosquito larvae will be interesting. Let the children experiment until everything lives and is in good condition.

### THE BALANCE OF NATURE (Pages 106–107)

Let the children suggest animals they know about that are killed for sport. Questions such as "Why aren't men allowed to kill ducks any time?" or "Why is a deer hunter allowed just one deer?" or "Why do you have to throw back fish under a certain length?" will start a discussion. The purpose is to help children understand why certain animals have become extinct in recent years, and to teach conservation.

The *Natural History Magazine* for March, 1939 had a splendid map showing animals that have become extinct in the United States and where they were last found.

A bulletin board with pictures of different plants and animals with a caption "What eats what?" could be arranged as a summary. Or lines leading from the animals to their food could be drawn.

## PROBLEM VII. HOW DOES THE BODY WORK? (Pages 108–143)

*Science Concepts*:

1. The skeleton is the framework that supports the body and is made up of bones.
2. The bones are covered with muscles, and skin covers the muscles. Muscles make movement possible.
3. The body needs food for growth, repair, and energy.
4. Well-balanced meals contain carbohydrates, fat, proteins, and minerals that are found in fruits and green vegetables.
5. Before food can be used by the body, it must be digested in the mouth, stomach, and small intestines.
6. Waste products are eliminated from the body through the skin, kidneys, and bowels.
7. Regular habits of eating, elimination, sleep, and exercise are very important to health.

This is a health problem and could grow out of the problem on plant food, the one about teeth, or could be introduced very naturally through the interest children have in their own bodies.

### BONES AND MUSCLES (Pages 108–115)

A sprained ankle, broken bone, or dislocated joint would arouse a discussion. In a third grade whose teacher broke her ankle, much interest was aroused by the cast she wore. The children had numerous questions about how the bone could grow together. They were interested in the fact that she had to take calcium tablets.

*Suggested Activities*:

In discussing bones, it is worth the effort to have some kind of skeleton or part of a skeleton to examine. Even chicken bones or a fish's backbone will help. Backbones of cows, sheep, horses, or deer are often found on the prairies, in wooded areas, or in the mountains. Lacking real bones, a good chart should be procured. These may sometimes be borrowed from doctors or the high school science department. Good charts of the bones of the feet and legs may be obtained free from companies dealing in orthopedic shoes. See appendix.

The children should notice how strong the bones are, yet how they are put together to make movement possible. The children can feel their own spines, bending as they do so, to feel the flexibility of the spinal column. They should discuss reasons for good posture as their bones are growing, and why they need to drink milk.

Let the children put their hands on their ribs and breathe so they can feel the motion of the ribs up and out. When they are slumped down in their seats, their lungs can't expand well.

They may observe the breathing of other animals and notice how the ribs rise and fall. Actual breathing is a mechanical process, initiated by a respiratory center at the base of the brain. The nerve impulse is to the muscles between the ribs (intercostal) causing them to contract. This raises the ribs, increasing the size of the chest (thoracic) cavity. This decreases the pressure between the inside of the cavity and the lungs. The greater pressure of the atmosphere outside of the body causes the air to go into the nose. If fourth-graders have learned about air pressure they can understand this if simply explained. If they try to raise their ribs without breathing in they can feel the pressure. Of course, breathing isn't usually a conscious act.

When discussing muscles, the teacher could show the children a soup bone with the meat attached to it. Many people don't realize that lean meat is muscle. Children wonder what muscles really look like—not realizing that they have seen them. A chicken wing (uncooked) or leg, or leg of a rabbit is good to use to show muscle. Butchers will often cut a bone with a joint to show the joint with the tendons, ligaments, and muscles attached. Children's interest and the fact that meat is familiar to them removes any feeling of repulsion that they might feel for a dead cat or mouse.

### FOODS THE BODY NEEDS (Pages 116–129)

The experiments with foods are a continuation of the ones the children did in the second problem. Here they are finding out more about cooked foods and balanced meals. The story is self-explanatory and is intended to be read by the children as they do the experiments. They will undoubtedly bring other things to school in addition to the ones suggested in the story.

The protein test shouldn't be done by children, but the teacher can do it for them. Egg white is a good protein to demonstrate the test. You will need nitric acid and ammonia for the test. Nitric acid will cause a bad burn if spilled, so handle it carefully. It will eat a hole in a piece of cloth or a wooden table top.

This is a good opportunity to discuss how to handle chemicals safely and to recall the fact that soda will neutralize acid. The ammonia should be tested to discover that it has the same reaction.

Put a drop of the acid on the egg white. It will turn the egg white yellow. Then pour a drop of ammonia on the yellow spot and it will turn orange. Since we know that egg white is pure protein this establishes the test. It can be used on other foods such as beans, peas, meat, cottage cheese, and milk. Beans and peas vary in their starch content, dried ones having more.

### HOW FOODS ARE USED IN THE BODY (Pages 130–139)

Digestion is the process by which foods are prepared for assimilation. This is accomplished by chemical agents in the digestive juices, known as enzymes. Enzymes are organic catalysts. This means that they start the chemical reaction but do not become a part of that reaction. They are not used up but continue to function.

Digestion starts in the mouth when saliva is mixed with foods in the process of mastication. Saliva consists largely of water, salts, and the enzyme ptyalin. Normally, it is slightly alkaline. Ptyalin works best in a slightly alkaline medium.

Ptyalin changes starch to sugar and if food were thoroughly masticated no starch would go into the stomach. The difficulty of doing this is demonstrated in the experiment suggested in this story.

Digestion isn't merely making food soluble, but that is the first step in the process. The sugar resulting from the action of ptyalin is soluble but it has to be further digested in the intestine before it can be assimilated. It has to be changed from a double sugar to a single sugar. Cane sugar is one of the double sugars, while glucose and the sugar in honey are single sugars.

All of this is too difficult for fourth grade children unless for some reason they know about sugar diabetes and have some questions about it. Blood sugar is a single sugar.

By doing the experiments suggested, children get the idea of chemical changes taking place in their bodies. These changes prepare the foods for use.

Cold water will not dissolve starch, but boiling water breaks down the walls of the starch grains and allows some of the starch to go into solution. Cooking starch may also change some of it to dextrin—an intermediate compound produced in the changing of starch to sugar. The purpose of the experiment is to give the children some understanding of why we cook starchy foods.

The experiment with the crackers is most interesting if every child has a glass jar (salad dressing jars will do), and each one chews as long as he can before spitting into the jar. When iodine is put on the chewed crackers, it will be evident which children did the best job of chewing. They should compare and discuss results. All will have noticed how sweet the cracker became.

In the fifth grade book, digestion is discussed in greater detail. The main ideas the children will get here are that foods are digested in the mouth, stomach, and small intestine. The teacher will need to know more and will find help in any physiology book. Stress *proper food* and *regular habits* rather than *medicine* for preventing constipation.

The answers to the questions on page 139 are:

1. Saliva
2. Digestion
3. Sweat
4. Urine
5. Stomach
6. Constipated
7. Intestines

### MORE EXPERIMENTS WITH FOOD (Pages 140–143)

These are activities which have value only as they help to answer questions the children may have as to the origin of our cereal foods. The activities integrate with social studies and the home arts, and help to answer questions as to why we can't make bread of cornstarch. Children in rural communities often chew wheat and discover that it is sticky. They also chew corn and discover that it differs from wheat. This may raise questions. Or they may wonder why we use flour instead of cornstarch in making paste.

In these days when bread, milk, eggs, and other foodstuffs come

in boxes from the grocery, perhaps children need to have some experiences as to their sources. City children may grow up rather ignorant of such simple information if we take too much for granted. One of the objectives of science teaching is to widen children's experiences and give meaning to the words they hear and read.

Washing flour as suggested on page 142, then repeating with cornstarch will help answer the question of why bread can't be made with cornstarch. If for any reason rye flour or potato flour is used in some homes, questions may be asked as to why wheat flour is added when bread is made. Washing small quantities of each will help answer. Gluten is necessary for the structure of the bread. The carbon dioxide from growing yeast blows little balloons in the sticky gluten, which harden as the bread bakes. The gas escapes. Without the gluten the starchy portion of the flour would collapse and make a hard, cracker-like substance. Rye flour has more gluten than wheat and is so sticky it is hard to handle without wheat flour, but bread is made of it. Potato flour has no gluten.

## PROBLEM VIII. HOW DO WE KNOW ABOUT THE ANIMALS AND PLANTS OF LONG AGO? (Pages 144–163)

*Science Concepts*:

1. Ancient animals and plants left a record of their structure in the rocks.
2. The remains or prints of ancient animals and plants are fossils.
3. Fossils help scientists to interpret the history of the earth.
4. The earth is very old, and life has been millions of years developing.
5. At one time in the earth's history, reptiles were the largest animals.
6. We do not know why dinosaurs and other prehistoric animals became extinct; it may have been
   *a*. Inability to meet changing climate.
   *b*. Inability to find enough food.

The purposes of this problem are to develop the understandings given above and to develop appreciation of the work done by scientists. The material offers opportunities for growth in the scientific attitudes of curiosity, search for truth, and for basing conclusions on sufficient evidence.

The best way to introduce the problem is by means of fossils. If you are near a museum, even a school museum, some fossils may be available. Most teachers aren't fortunate enough to be able to take the children to see dinosaurs in the larger museums. But even the fossil ferns found in coal, the shell prints in limestone, or prints in sandstone and shale will serve to arouse interest.

An example of one way this problem originated in a fourth grade may illustrate. The teacher brought a fossil that had been found in an old river bed. A newsboy had found it and thought it was the backbone of a fish. The teacher recognized it as a primitive cephalopod, that prehistoric relative of the modern chambered nautilus. She took it to her fourth grade with the story of how it was found and what the boy had thought. She challenged them with "How do you suppose I knew this was not a backbone of a fish?" Here was an excellent problem for children who had just been studying human backbones. They examined the fossil and compared it with the backbones of a deer and a cow which they had in the room. They discussed the possibility of its being the backbone of some animal similar to a fish. They discovered that it was not made of segments, like vertebrae, but that it had cross walls. The teacher had the shell of a chambered nautilus which had been cut to show the cross walls. The purpose was not to teach the children the name of that particular fossil but to arouse interest. Following the discussion of the cephalopod, several children told of fossils they had seen. Thus stimulated, many questions were asked about fossils.

The type of activities depends upon available material. In the northern part of the United States, glaciers deposited sand and gravel containing many fossils of primitive animals. Gravel pits or banks of rivers, or road cuts have often exposed these fossils. By doing a little scouting around, teachers may locate some such places near enough to visit.

Near the Rocky Mountains, layers of limestone, shale, and sand-

stone have fossils in them. The story in the book is taken from an experience of one of the authors who was teaching in Wyoming.

In Kansas, Nebraska, and other states, chalk beds contain many fossils of primitive camels, and simpler forms. In California are the famous Le Brea tar pits where primitive carnivorous animals have been found. In several states petrified forests are located, fossils of primitive trees. So a teacher need only do a little investigating to find local material. She may learn where these places are by writing to the Geology Department of her State University or by consulting an historical geology book.

## PROBLEM IX. HOW SHOULD WE CARE FOR FOOD? (Pages 164–183)

*Science Concepts*:

1. Foods spoil because of plants that are growing on or in them.
2. These plants are not green so therefore are not able to make their own food.
   *a.* Mold is a plant that grows on many kinds of food. It reproduces by spores.
   *b.* When preserving fruit or juice, we sterilize the cans to keep out mold and bacteria.
   *c.* Bacteria are tiny plants that may make foods spoil.
   *d.* We keep foods clean and cold to prevent the growth of mold and bacteria.
   *e.* Bacteria are so small one needs a microscope to see them.
   *f.* Pasteurization is a way of making milk safe to drink.

This is an excellent problem to stimulate interest in cleanliness. Fourth-graders are fascinated with a microscope and things too small to be seen without one. It appeals to their imaginations. Admonitions to "wash your hands before you eat" are much more impressive after one has seen what grows from the dirt on his hands.

### WHY DOES FOOD SPOIL? (Pages 164–175)

This could very easily grow out of the earlier problem on foods.

A simple way to introduce it is with some moldy bread or jam. It might follow a discussion of yeast. Bacteria, yeasts, and molds all belong to a very simple group of plants—the fungi. Fungi belong to the lowest phylum of plants, Thallophyta. To this phylum also belong the algae, green one-celled plants, many of which are found in ponds and look like green scum. Algae furnish food for many of the pond animals.

Fungi are not green and so are unable to make their own food. Yeast plants live upon the sugar in the bread dough or other medium in which they are growing. They reproduce by budding. As they digest the sugar, they release the carbon dioxide by which the dough is raised.

Molds are fungi which reproduce by spores. Spores are single cells that are able to grow and produce new mold plants. Each mold plant consists of a mass of thread-like hyphae, called a mycelium. The mycelium grows down into the bread or jelly or other host and there absorbs food. Stalks grow up from the mycelium with spore cases on them. These spore cases may be black, green, or some other color and give the characteristic color to the mold.

Bacteria are the tiniest of known plants. They also feed upon the host on or in which they live. In their digestion they release different compounds, some of which cause the odors in spoiling food. Disease bacteria produce toxins which make the victim ill.

Bacteria reproduce by a splitting process called fission. There are so many kinds of bacteria that their reproduction, their minute size, their inability to make food, and their shapes, which are always spherical, rod-shaped, or spiral, are the only characteristics they have in common.

*Suggested Activities*:

The children should be allowed to grow mold on bread. If bread is put into a warm, damp container away from the light, mold invariably grows upon it. A little of the black spore cases transferred to fresh bread will grow in an incredibly short time.

The white, cottony mycelium or vegetative part of the plant is easily seen through a hand lens. To see the spores, it is necessary to use a microscope.

If this is their first introduction to a microscope, the children will need a little help. The teacher should mount a little of the mold in a drop of water on a slide, trying to have it look as nearly like the picture on page 175 as possible. Then with the picture in mind the children will know better what to look for.

If they are told to put a hand over one eye and look with the other, they won't squint. Turning the head to one side and looking through the corner of one eye also helps in learning to keep both eyes open.

Children never grow tired of looking through the microscope, so if you have one available, make the most of it at this time. A drop of water from a pond or the aquarium is always exciting. A piece of butterfly wing, a hair, thin slices of potato, carrot, or onion are all good. To make these slices, use a razor blade and make them as thin as possible.

A little yeast may be crumbled in some sugar solution and allowed to stand for a few minutes. A drop of the mixture on a slide will show the yeast plants. You may even see some budding.

To make the slides of pollen, just dust a little from a flower into a drop of water. The fern spore cases are the brown dots on the underside of a fern leaf. Scrape a dot off with a needle and carefully tease it apart in a drop of water. The picture shows the spore cases under high power.

The bacteria shown on page 175 are from stained slides, under high power. All of these bacteria are too small to be seen unless so treated. In decaying plants found in puddles, we often find bacteria large enough to be seen under low power.

Bacteria may be grown on gelatin if the children have not previously had this experience. To make the gelatin culture, you will need a package of gelatin or agar; a quart of boiling water; a half ounce of beef extract or bouillon made with a bouillon cube; a pinch of salt; a little soda; a half ounce of peptone (this may be bought at a drug store or omitted if not available); test tubes, Petri dishes, or flat-sided bottles which may be laid on their sides.

Make the medium as you would plain gelatin. Agar-agar is a gelatinous material made from seaweed which may be used instead of gelatin.

Sterilize the glassware in a steam sterilizer, pressure cooker, or by boiling, just as you would for canning. Fill the test tubes about ¼ full, plug with cotton and again sterilize. Lay on a slant to cool.

Make a needle to use in inoculating cultures by inserting the eye end of a darning needle into the end of a stick—the rubber end of a pencil will do.

Inoculate the gelatin by first passing the point of the needle through a flame (match or candle), cool, take a little dirt from under a fingernail on end of needle. Take the cotton plug from a tube, being careful not to touch anything with the end that goes into the tube, and lightly make a line on the surface of the gelatin with the infected needle. Re-plug the tube, pass the needle through a flame, and put the tube in a warm dark place to incubate. This process may be repeated for every child—the tubes marked with name or number on a gummed sticker, and all tubes placed upright in a coffee can or other container. A dark closet is a good place to put them. In two days there should be some growth of organisms from the dirt. There may be fungi, like molds, or colonies of bacteria that are like glistening drops, white, yellow, gray, or other colors. Cultures may be made from other sources, also, such as coughing into some, letting a fly walk on some, putting a hair or a pencil point into some, and so on.

After the cultures have grown, if a microscope is available, with a sterile needle remove some of one patch of fungus or colony of bacteria to a slide with a drop of water on it. Examine under the microscope. Be sure to plug the tubes after removing anything and when you are through with them, steam or boil to kill any disease organisms which may be present before unplugging and cleaning. If this isn't possible, cover the tubes with a strong solution of chlorox and let stand overnight.

Although it may be impossible to be sure that everything you use in these experiments is absolutely sterile, the effort you make will teach the children the technique. Actually seeing what will grow from these various sources makes an impression on children. They have been known to break themselves of biting nails, chewing pencils, and sucking fingers after seeing the "germs" that were there.

## PASTEURIZED MILK (Pages 176–179)

Most children have used Pasteurized milk and may have wondered how it differs from other milk. This story brings out the importance of Pasteurization and shows a simple picture of the process. If there is a creamery near, it would be a splendid activity to visit it and see how milk is cared for. Some of the creameries have free charts which the teacher may obtain if a visit is impossible. Much free material may be obtained from The National Dairy Council.

An experiment which always impresses children with the value of clean milk is to get two bottles, one of raw milk and one of Pasteurized. If the raw milk comes from a farm where it isn't handled carefully, all the better. Let the two bottles of milk stand in a warm room for twenty-four hours. Then smell the two. If the raw milk isn't clean, bubbles of ill-smelling gas will usually be formed as it sours. These are due to the presence of bacteria that are found in the intestinal wastes of animals. The gas indicates contamination with manure or soil from the barnyard. In themselves, these bacteria may not be harmful but where they are, other harmful bacteria may be present. Consequently, we don't want to use such milk. Pasteurization kills disease-producing bacteria and inhibits the growth of others. It does not kill the lactic acid bacteria which cause the souring of milk, but slows them down.

## LOUIS PASTEUR (Pages 180–183)

This is a good opportunity to begin building appreciation for the good done by great scientists.

In teaching this story, the teacher should lead the children to analyze the experimental techniques used by Pasteur. Some of these are:

1. The invention of the flask to prevent contamination.
2. The careful way in which he insured sterilization.
3. The patience with which he waited to see if the broth spoiled.
4. The shaking of the flask to touch the dust.
5. The patient waiting for results.
6. The repetition many times before coming to a conclusion. Repetition in different situations. Checking of his results.

7. The application of what Pasteur had learned to saving human lives.

No story demonstrates scientific method any more simply than this one of Pasteur's. Fourth-graders are old enough to understand and be excited by it. The teacher should read a good sketch of Pasteur's life and work in one of the books suggested in the bibliography so she can supplement the story the children read.

## PROBLEM X. HOW DO ANIMALS SPEND THE WINTER? (Pages 185–191)

*Science Concepts*:

1. There are many interesting things to see on a field trip in winter.
2. One can read the story of animals' activities by their tracks in the snow.
3. Most wild mammals hunt their food at night.

This is really a continuation of Problem VIII and contributes to the understanding of the principle of survival. It helps to develop appreciation and careful habits of observation. Once introduced to the idea, children come to school anxious to tell about the stories they have seen in the snow.

### WINTER'S PICTURE BOOK (Pages 185–191)

*Suggested Activities*:

A bulletin board with tracks going across it, and the caption borrowed from a well-known children's book *Who Goes There?* started several groups of children on track quests.

A trip after a light snowfall will usually arouse much interest in tracks, especially if before going the teacher says something like this, "As I was walking down the path this morning, I saw that something had been there before me. How do you suppose I knew?" After their discussion, they will all be eager to go out and see if they can recognize the maker of the tracks.

After this when the children try to describe tracks they see, they should draw them on the board so the class can help to decide

what animal made the tracks. The teacher can make these real problem-solving lessons by insisting on *careful* observation, basing statements on *evidence* and finally checking with a good book on tracks before coming to a conclusion. Some questions which may stimulate problems are "Was the horse trotting, walking, or galloping? How do you know? Which way was the rabbit going? Was the dog hunting a rabbit or just out running around?"

The teacher must keep in mind that track study and identification are not ends in themselves, but merely ways of gathering information to help solve problems concerning the habits of animals. Track study and identification may lead to interesting leisure time activities and also have other concomitant values. Teachers will find suggestions for these in some of the references.

This isn't a subject upon which too much time needs to be spent. After it is introduced, it may be discussed briefly, every time some interesting tracks are observed. If a portion of each class period is devoted to individual reports of science experiences, tracks will be reported at that time. The rest of the group may be asked to help interpret these experiences.

## PROBLEM XI. HOW CAN WE LEARN ABOUT THE WINTER SKY? (Pages 192–210)

*Science Concepts*:

1. Groups of stars are called constellations.
2. The Big and Little Dippers are in the northern sky the whole year; they are in different positions at different seasons.
3. It is the earth's movements which make the constellations seem to move across the sky.
4. If one knows the stars, he can tell directions by them.
5. Orion, Taurus, and The Seven Sisters are winter constellations.
6. A telescope is an instrument men use in studying the stars.
7. The Milky Way is made of countless stars.
8. Sirius, the Dog Star, is the nearest and brightest of the stars we see.

Because of their beauty and mystery, the stars appeal to the imagination of a child of this age. Children begin to show interest in the sky before they come to school. As their knowledge grows they travel farther and farther into space. Their universe grows larger. Thus any study of the stars helps to develop one of the major concepts of science—that space is vast.

Teachers sometimes hesitate to introduce a problem on stars because they can't take the children out to see them. An early evening trip is desirable, but if it isn't possible you can still arouse plenty of enthusiasm through individual observation.

One way to introduce star study might be to say, "Last night about eight o'clock I was looking into the sky. I saw a picture that had this pattern," drawing the Big Dipper on the board. Most children know the Big Dipper and will recognize it. Then the teacher may ask someone to point toward the part of the sky where it is located. This will start much discussion, especially since many children mistake Orion for a Dipper.

If they disagree, leave it with the suggestion that all look that night and report the next day. Many of them will see other constellations, and after the discussion the following day the class will be ready with questions.

*Suggested Activities*:

The best activity for learning the stars is to look at them, then try to draw them on the board. After that the class can help to locate the constellation on a star map. The little ten-cent *Seeing Stars* from the Harter Publishing Company has good maps in it. The *Science News Letter* and *Nature Magazine* publish star maps each month. So do many newspapers.

If you have a reflecting lantern, you can project one of these maps on a large sheet of paper and make a large map that will be easy for all to see, or a large copy can easily be made on the blackboard. Put in only the constellations the children know at first. Then add others as their interest and knowledge grow. The teacher must be prepared to hear and see many repetitions of the Dippers and Orion. Each child who sees a star pattern for himself is a discoverer and no matter how many others have told about that same group, he must make his contribution and be assured

that he is correct. It is just an evidence of what all teachers know, that we rarely teach more than one child at a time. Each child learns at his own rate of speed, when he is ready to learn. He may listen to the others tell what they have observed but only when he experiences it himself does it have meaning for him.

If it is possible to take the children for a short evening trip, some children will see constellations for the first time. The place should be a spot that is high enough to see most of the sky, open, not full of trees and as far from bright lights as possible. A park, big lawn, field, hill or ballground may be good. In winter, seven o'clock is late enough to see many stars and it is interesting to be there at twilight and watch the stars "come out."

The teacher should make arrangements with parents and ask them to come if they care to. A half hour's observation is sufficient time to point out the main constellations. Discussion should be reserved for the following day at school. If a child has trouble seeing a constellation, try to find something like a tree or building which is in line with it and ask the child to start with the object and follow as you raise his arm along the line.

The experiment which Jack does on pages 206–208 should be carried out in the schoolroom to help children understand why certain constellations are visible only part of the year. The reason for our being able to see the circumpolar constellations all year in this hemisphere is that the pole star is in line with the North Pole. To demonstrate this, the child doing the experiment should look at something on the ceiling, like a light globe. He will see that he could see the light globe from any position. Because of the tilt of the earth's axis, the polar star would be directly overhead only at the pole, and south of that will vary in position from season to season.

Betelgeuse, the red star in the shoulder of Orion, is the second largest star that we see. Our solar system past the earth's orbit would go inside of Betelgeuse. It is pronounced Bĕtelgĕrz or Bĕtelgēēz.

At this age children do not usually have patience enough to make individual maps, but if they want to, let them make simple ones with only the few constellations they can locate.

This is one place in science where myths have a place. Because

the names of the constellations come from these legends, we use them in connection with star study. It is strange, but children often see the pictures in the constellations that the myth tellers saw, even before they hear the myths.

## PROBLEM XII. HOW DO THE SUN AND MOON AFFECT THE EARTH? (Pages 211–223)

THE SUN, THE MOON, AND THE EARTH (Pages 211–218)
THE ECLIPSE OF THE MOON (Pages 219–223)

*Science Concepts*:

1. The earth's pull is called gravity.
2. Gravity holds everything on the earth to it.
3. The earth's gravity keeps the moon revolving around it.
4. It takes the moon about a month to travel around the earth.
5. The moon shines by reflected light.
6. When the moon is between the earth and sun so that its shadow is on the earth, we have an eclipse of the sun. When it is on the opposite side so that the earth's shadow is on the moon, we have an eclipse of the moon.

*Suggested Activities*:

The teacher needs to be sure that the children get correct concepts in this story. Be careful about the concept of gravity or children will confuse it with magnetism. Magnetism pulls only iron, steel, cobalt, and nickel. Gravity pulls everything to the earth.

Also, the children will need help in understanding the demonstrations. The one with the string and eraser may give the idea that gravity is a string. The teacher should use as many simple examples as possible to demonstrate the concept.

Although the idea of what makes the moon shine is presented in the primary books, it needs to be repeated in different ways many times before children understand it. Sometimes children get the idea of reflection by holding something near a spot on a white wall that is in direct sunlight. They can see the light reflected from the wall to the object.

In demonstrating an eclipse of the sun, children often are confused because they know that the moon is smaller than the sun. They can't understand how it could obscure the sun. The teacher may have them take some small object like a ball and discover that it can shut out the light from a big lamp by getting it close enough to their eyes.

If there should happen to be an eclipse of the sun, the children should observe it through two thicknesses of a black film or a smoked glass, never through colored glasses. An eclipse of the moon is well worth an evening trip.

The reason we don't have an eclipse every month is that the moon's orbit is not on the same plane around the earth from month to month. It is as though the plane tilted up and down, making the moon go on a spiral stairs. This is too hard to explain to fourth-graders but they can understand that the moon is sometimes too far up to cast a shadow on them, if they move their fists above the line of the light from the "sun" as they do the experiment on page 216. As they move their fists down, they will see that at one point the "sun" is blotted out, but it is soon seen again.

## PROBLEM XIII. HOW DOES THE EARTH'S SURFACE CHANGE? (Pages 225–235)

*Science Concepts*:

1. Freezing water breaks up rocks.
2. Melting snow and rain carry soil away to new places.
3. Glaciers crush rocks and carry them to new places.
4. The northern part of the United States was covered by huge glaciers in prehistoric times. They changed the earth's surface.
5. Erosion is the wearing away of the land.
6. Rivers start as small streams that grow larger.
7. Rivers can wear gorges through solid rock.

The purpose of this story is to help develop the concept that the surface of the earth is continually being changed. It may be introduced in many ways. You can usually find rocks that have been weathered. Let the children look at one and compare with a rock

that isn't weathered. Ask the questions "How did this happen?" and "What makes the difference in these two rocks?"

*Suggested Activities*:

A trip out-of-doors when the snow is melting will illustrate the way water makes gulleys as it runs downhill.

If a river is near, a trip to it may afford a chance to show how a river meanders and deposits sand bars.

Perhaps you live in the glaciated region and can find smooth rocks with glacial scratches; or perhaps you can visit kames and moraines. The Great Lakes region shows excellent examples of the work of ice. The West and Southwest have splendid examples of wind erosion as well as the work of floods.

There is a splendid opportunity in this problem to teach soil conservation. See the reference list for material which the U. S. Department of Agriculture will send.

The teacher should bring this problem right down to the region in which she is teaching. If she doesn't know the geological history of the region, she should send to the United States Geological Survey for the Geological Survey of her state. The state universities and agricultural and mechanical colleges often have helpful material. A question, "What do you suppose this spot was like a thousand years ago?" will stimulate thinking and discussion.

In rural areas, teachers may have an opportunity to do something about the problem of erosion. One rural school was situated on a sandy hill. Rains were making deep gulleys down the terraces around the yard. The teacher and children discussed the fact that their school grounds were being carried away and decided to try to stop it. With the help of a few of the fathers, they planted sod on the terraces and along the edge of the playground. The whole school helped water and care for the grass until it was well rooted.

## PROBLEM XIV. HOW SHOULD ONE HANDLE TOOLS? (Pages 237–243)

*Science Concepts*:

1. We should learn to use tools properly.

2. Some tools are sharp and might cut one.
3. Some tools may cause bruises or broken bones if handled carelessly.
4. In a workshop, everyone should cooperate to make it safe.

*Suggested Activities*:

This is a safety lesson to help teach children the importance of using tools carefully and putting them away properly. Not all schools have workshops but most of them provide some tools and facilities for using them.

The teacher may motivate a problem when the need arises. Need for use of scissors or knives may provide an opportunity for her to say "I wonder if we should discuss these things before we use them?" or "Not everyone knows how to use scissors or a hammer or a screwdriver. Would someone who does know like to show us how?" After discussing the tools, the children may read the story to see how it compares with their ideas. Ordinarily we don't approve of honor rolls but since the one suggested in the story is to stimulate accident prevention and may be attained by even a dull child, it may serve a purpose.

## PROBLEM XV. HOW DOES LIGHT HELP US TO SEE? (Pages 245–253)

### RAINBOW COLORS (Pages 245–253)

*Science Concepts*:

1. Light makes it possible for us to see.
2. Light is reflected when it strikes an object and comes back to the eyes.
3. White objects reflect all of the light; black objects none or little.
4. Light may be broken into rainbow colors when it strikes water drops.
5. Dust reflects light and makes it possible for us to see the beam.
6. A prism will split a ray of light into the colors of the rainbow.

7. All the colors together make white.
8. Light goes through some objects, such as glass.

This story goes on with the development of the concepts of light begun in the previous grade. It might be introduced by a discussion of the colors of different objects in the room, by the color bands often seen when the sunlight strikes the edge of a glass jar, vase, or aquarium. Some child may want to know what makes the colors on the pavement where oil is standing.

A good question might be: "What colors would the things in this room be at night?" "Why?"

*Suggested Activities*:

The children should carry out all the activities suggested in the story. If the room is darkened, and a small beam of sunlight allowed to come through a hole in a curtain, it will be much easier to perform the experiments. Some chalk dust will make the beam visible.

You can use a mirror to throw the beam in any direction you wish it to go. If sunlight does not come into the room, a child can throw a beam into the room from outside or the whole class may go out-of-doors.

Rainbows are not just spectra as are those made by allowing a beam of light to pass through a prism. But the experiment with a prism helps to clarify the concept that white light is composed of colors.

When a beam of white light enters another medium, such as water, its speed is changed and the beam is bent. If instead of going into a flat piece of glass or a plane surface of water, it strikes a curved surface or a piece of glass shaped like a prism, the entire beam isn't bent equally. The longest waves in the beam are bent least, the shortest ones the most. Red rays have the longest waves and therefore come out with the least refraction, while violet rays have the shortest and come out with the most refraction. The other colors range in between.

In a rainbow each water drop causes the beam that strikes it to split. The colors are reflected to the eye from the back of each drop. We see it as a bow because of the angle of deviation of the light rays as they are reflected to our eyes. All the red from many

drops are the same wave length and assemble in a band. The other colors do the same thing. No two people see the same rainbow since they are standing in different spots.

A color wheel is easily made by using a stiff piece of cardboard and coloring it like the picture on page 253. It may be mounted on a toy motor and attached to a dry cell. Then it will spin fast enough to appear grayish or maybe white if the colors are pure enough. A color top is an excellent device to use to demonstrate the same principle.

If two prisms are available, try holding the second prism in the path of the beam as it comes out of the first prism. When the two sides are held together so that they make a four-sided figure, the light will come out white. The waves have been reassembled in the second prism.

## PROBLEM XVI. HOW DO PLANTS USE STORED FOOD IN SPRING? (Pages 254–281)

*Science Concepts*:

1. The stored starch in plants has to be changed to sugar before the plants can use it. This is digestion.
2. In sprouting seeds the starch is being digested to feed the developing plant.
3. In the spring the starch that has been stored in the stems and roots of trees is being changed to sugar, and is moving up to the buds. It is called sap.
4. Man uses this sugar from maple trees.
5. Other sources of sugar are sugar cane and sugar beets.
6. Sugar beets store sugar in their roots, while sugar cane stores it in its stems.
7. Many common weeds store food in their roots and are able to bloom earlier than those depending on seeds.
8. Trees use their stored food to produce the first leaves and flowers in spring.
9. We tell trees apart by their leaves, buds, flowers, and bark.

The purpose of this problem is to help develop further the principles of growth in plants and man's dependence on plants. It also helps develop appreciation of that dependence. Knowing that

plants have processes similar to those of animals makes children better understand their own life processes.

### THREE KINDS OF SUGAR (Pages 254–263)

In almost any part of the country, children might have the experience of making sugar from one of the three sources given in the story. They may be able to visit a factory where sugar is being made. In so far as possible they should carry out the activities suggested, or similar ones.

Sprout wheat or oats on wet blotting paper, sawdust, or cotton. The children should test it in different stages of sprouting as the starch gradually disappears during the growth of the plant. They may taste some of the grain sprouts to learn that they are sweet. If some seeds are left on the blotting paper until they die, the children will see that the plant has to have soil after all the stored food is gone.

Maple twigs show starch storage in winter. Split the twigs and drop the iodine on the split surface. After the sap starts flowing in the spring, no starch will be present.

The starch has been stored in a layer called the starch sheath which is around the vascular tissue; some is also stored at the base of the buds. In spring when the ground warms up, water begins to enter the root hairs of the tree. This water is a necessary material in starch digestion. Enzymes in the cells containing the starch cause water to combine chemically with the starch and produce sugar. In trees, large amounts of starch are stored in the roots. Hence in spring, sugar solution is being carried upward to feed the buds. Not until the leaves are formed can food manufacture start. By that time all of the sugar will have been used and the ascending solution will no longer be sweet. For the rest of the season the sugar solution will be moving downward from the leaves where it is made. Recent experiments have shown that enough starch is stored at any point along the trunk to produce a great deal of sap. As the children in the story learned, sap has a large amount of water in it.

Sap is never very concentrated, so it takes large quantities to make even a little sugar. This will be impressed upon the children when they tap a tree, collect and boil down the sap.

To tap a tree, select a hard maple and bore a hole with an auger into the vascular layer. This is just under the bark. The south side of the tree is best since it gets more of the warm February sun. Insert a spile, usually made of tin, into the hole. It should fit snugly so the sap won't leak. The hole should be high enough so that dogs can't drink from the pail that is hung on the spile or hook above it.

When through collecting sap, the spile should be removed and a cork or plug of wood pounded into the hole.

The brown color and characteristic taste of maple sugar are due to minerals and other impurities in the sap. If it were refined, maple sugar would be as white as other sugar.

### THE LETTER FROM THE SOUTHWEST (Pages 264–268)

In parts of the country where sugar beets are raised, the children may visit a farm and see the beets growing. Later they may visit a sugar factory and see the process of sugar refining. Many sugar companies will send charts and pamphlets to teachers.

Sugar beets may be obtained, run through a food chopper, and the juice extracted. The juice may be filtered and the water evaporated to obtain sugar crystals.

Filter paper is useful in many simple experiments, and may be obtained from a scientific supply house.

### ROOTS THAT STORE FOOD (Pages 269–270)

In early spring it is always surprising to find many common weeds blooming as soon as the snow melts. The children should take a trip to find and pull up as many different plants of this sort as possible. When they see the long thick roots, they will understand why merely cutting off the tops of these weeds does not kill them. Roots of common vegetables, such as carrots, parsnips, sweet potatoes, and turnips may be put into water and their growth observed. All these plants are biennials, storing food the first year and producing flowers the next. Sometimes children find one of these plants in bloom, when it has been left in the ground all winter. If the root is dug, it will be found to be quite different from the carrot or parsnip that we eat. The stored food has been used to produce leaves.

## A TRIP TO THE WOODS (Pages 271–281)

There is no particular value in teaching children the names of trees as a mere exercise in identification. Although some children may enjoy tree study as a leisure time activity, it has to serve some more definite purpose to make it worth while as a part of a teaching unit.

This story contributes to the solution of the major problem by showing how trees use the food stored the season before. It also brings in the interrelationship between flowers and insects. Children seldom recognize the flowers of trees. They know that bees help to cross-pollinate garden flowers. Here they learn that butterflies also get nectar from flowers and aid in cross-pollination. They also learn that all flowers are not showy.

Although the story uses maple trees to illustrate the life processes of trees, any local trees may be used as teaching material. The main objectives are to develop appreciation of the beauty and usefulness of trees, to understand their life processes, and to gain practice in scientific method.

*Suggested Activities*:

The story might be introduced by a remark by the teacher: "I wonder what has happened to the tree we tapped a week ago," or "I saw thousands of flowers in bloom as I came to school. What do you suppose they were?"

The activities suggested in the story may be carried out. Maples are easy to identify because of their opposite buds. Only three groups of native trees in the United States have opposite buds, the maples, the ashes, and the buckeyes. Having decided that a tree belongs to one of these groups, a key to local trees will help with the species. Many state departments of agriculture issue bulletins of trees of the state. The American Tree Association has tree guides, also.

Several games may be played that will teach accuracy of observation and at the same time be enjoyed by the children. One of these is "spot the tree." The leader stands in the center of the group and says "From this spot I can see a tree with opposite leaves. The trunk is gray at the bottom and light gray at the top. Find it." The first person to touch the right tree is leader.

Another is the old game of "match-it." A leaf is given to each child. He finds a tree with a leaf to match it. The trees should have labels thumbtacked to them and the child reads the label, comes back and tells the teacher what kind of leaf he has. He may be asked to also tell one other characteristic of the tree.

Another game is to have each child choose a partner. Give each pair a slip of paper with a direction something like this: "On a maple tree near the southwest corner of the school yard, you will find a note. Do what it says." The note may say "Walk east down the path past an oak tree. Look under a stone south of the tree," and so on. To simplify this for the teacher, half of the class might prepare the trail for the other half.

A tree trail may be made by fourth-graders and will prove interesting to others as well. As a tree is studied, some of the unusual things about it may be printed on a card, shellacked or covered with plastic, and tacked to the tree. The card might say something like this, "This is a yellow pine tree. It must have very sweet sap. Look at the trunk above your head and see the little wells made by sapsuckers. Compare its needles with the tree beside it." On the tree beside it might be this card, "Feel the needles of this tree. Look for little blisters of pitch on the trunk. Break one and smell it. This is a balsam fir tree. Its needles are flat and soft. They are not in bundles like the needles of the pine tree."

Teachers must be careful not to become so enthusiastic about identification as to kill the children's interest. Some of the children may wish to collect leaves, press and mount them. But most children of this age will lose interest if required to do much of such busy work. The emphasis should be placed upon the value of trees and their activities.

## PROBLEM XVII. HOW CAN WE KNOW THE WOODPECKER FAMILY? (Pages 282–297)

*Science Concepts*:

1. The members of a bird family have common characteristics.
2. The woodpecker family is known by: strong, chisel-like beaks; stiff, pointed tail feathers; hard pointed tips to tongues; two toes forward and two back.

3. Woodpeckers eat many insects which they spear with their tongues.

THE DRUMMERS (Pages 282–289)

The purpose of this story is (1) to add to the understanding of bird habits, (2) to help the children develop further the skills needed in scientific method (problem solving), and (3) to develop appreciation for the good done by birds even though some may occasionally do harm.

*Suggested Activities*:

The problem should be introduced at the time when these birds are drumming to announce their territories. If the teacher will locate such a bird and observe for a day or two, she will discover that the bird returns to his drumming site time after time. She can then take the children to the spot and watch for the bird.

Yellow-bellied or red-naped sapsuckers may be located making their little wells along the sides of trees. Since the birds make these wells and return to drink sap from them, the teacher may be reasonably sure that the children will see the birds.

The teacher may say, "You were tapping a maple tree last week. I saw another tapper busy on a tree, this morning. What do you suppose it was?" When the children have guessed a few times, she may add, "If you would like to see it, I think I could show it to you. However, it is very shy and easily frightened." This should stimulate the desired response—that they will be cautious and quiet.

Woodpeckers are so common that representatives are found in most places. With the exception of the three-toed woodpeckers, all of them have two toes forward and two back. With these and their stiff tail feathers they brace themselves against the tree and drive their chisel-like beaks up and down with the speed of a riveter. Having made a hole above an insect larva, the bird spears it with its tongue. The tongue is mounted on a slender Y-shaped hyoid bone that makes it possible to stick the tongue out farther than is possible with other birds.

It should be brought out that while sapsuckers do harm trees to some extent in the spring, they are insect eaters the rest of the year. In few places do they do much damage.

With the exception of the red-headed woodpecker, the birds mentioned in this story show color differences in the male and female. Children are usually interested in discovering these differences.

### A PAIR OF FLICKERS (Pages 290–297)

This story is for the purpose of giving the habits of a common member of the woodpecker family. Flickers are found in most parts of the United States and are easily observed as they feed and build in yards, orchards, and other familiar places. Early in the spring they may be heard drumming from the tops of telephone poles, trees, and buildings.

Soon after this choosing of territory, the birds may be seen courting the females. This is an amusing activity and always interests children. Ornithologists have differing ideas as to the reasons for the behavior of these birds.

*Suggested Activities*:

Flickers sometimes make their nest holes near enough the ground for the children to be able to see into them. The nests may be located by the chips on the ground. If a nest hole is discovered, try listening with an ear against the tree trunk. It is best when studying birds in the field to stand or sit quietly for a while in sight of the nesting tree. Thus the birds won't be frightened and will come back to the nest.

A record should be kept of the things seen on each trip. This may be a group record and will help teach children to gather and record accurate data.

After a first trip to observe birds, the children should discuss and formulate questions about things they want to know. Usually these questions will include some about birds in general, as, for example, this list made by a fourth grade:

1. Why do woodpeckers build deeper nests than other birds?
2. How do the little birds develop inside the egg?
3. Why do eggs have to be fertilized in order to grow?
4. How do birds feed their young?
5. How do birds know when to fly south?

This is just a partial list but illustrates the ability of children to formulate good problems after some experiences that help to direct their interest. These children had been watching the courting activities of flickers. They also had an incubator in which eggs of chickens, ducks, and turkeys were being incubated. Candling of the eggs at the end of a week showed which ones contained embryos.

To help answer the questions on development, some eggs were opened on succeeding days to show the developing chick. Since the children were worried because the developing embryo was killed, the opening of the eggs was discontinued. The teacher found some colored pictures from an issue of *Life* showing the same thing. These satisfied the children and eliminated their worry over killing the embryo chicks.

A good movie in color, showing the formation of eggs in a hen, was obtained free from the Purina Company. It helped to answer many questions that arose in connection with questions involving reproduction. All the activities involved in this problem are wholesome contributions to sex education.

## PROBLEM XVIII. HOW DO WE GET FRESH AIR INTO BUILDINGS? (Pages 298–303)

*Science Concepts*:

1. The air near the ceiling of a room is warmer than near the floor.
2. When a window is opened at the top and bottom, fresh cold air comes in at the bottom and pushes the warmer stale air out at the top.
3. This exchange of air is called ventilation.
4. In large buildings, ventilation is accomplished by means of fans. The fans force the warm, stale air out of the building, and washed, cooled or fresh air in.

### RANDY'S EXPERIMENT (Pages 298–303)

This story may be used at any time of the year. It gives children the principles of ventilation. It shows a simple, practical way to ventilate a room at home, and one mechanical device.

*Suggested Activities*:

Lighted candles may be used instead of sticks with tissue paper streamers. However, since candles involve danger of fire, they should be used only under close supervision by the teacher. A stick of smoldering punk or incense may be substituted. The smoke or flame will demonstrate currents much better than paper.

The teacher must be careful to have the children get the correct concept concerning warm air. Warm air expands and becomes lighter than the cold air, and is therefore pushed up by the heavier, cold air, is the concept that should be stressed. It doesn't just rise against gravity.

If there is a ventilating system in the school or in any near-by building, it should be visited and examined. Sometimes it is possible to visit a building that is under construction and see the whole system being installed. So many of our modern homes are air-conditioned and heated through the use of fans and the principle of convection that it is easy to find applications to the lives of children.

## PROBLEM XIX. HOW DO MAGNETISM AND ELECTRICITY AFFECT OUR LIVES? (Pages 304–327)

### SUB-PROBLEM. HOW ARE MAGNETS USEFUL? (Pages 304–314)

*Science Concepts*:

1. Men tell directions by the compass.
2. The compass needle is magnetized steel with north and south poles.
3. Magnets may be straight or U-shaped.
4. Magnets attract iron, steel, and a few other metals.
5. Magnets attract through glass, tin, and paper.
6. Filings are attracted to the poles of a magnet in a circular field.
7. When a bar magnet is suspended and swings freely, it points N and S.
8. Like poles of magnets repel each other, and unlike poles attract.

9. Other pieces of steel can be magnetized by rubbing them on the pole of a magnet.

### THE COMPASS (Pages 304–314)

This story enlarges on the concepts of magnets taught in the primary books. Fourth-grade children have many questions about magnets and the compass. Recently a number of toys have appeared that use the principle of magnetism. The little magnetized dogs that turn around when placed facing each other are an example. The question "Why do the dogs jump like that?" is a good way to start the discussion.

*Suggested Activities*:

Since the children may not have learned about magnets before this experience, the teacher should discover what they know. She may allow them to repeat the activities given in the primary manuals.

When the children know that magnets are pieces of steel that attract iron, steel, and two other metals (cobalt and nickel), they are ready for the experiments described in this story.

To set a problem, the teacher may have a strong magnet hidden in the drawer of the table where the children work. A compass placed on the table will vary as it is moved to different places on the table. When taken to some other table, it will point north. This may puzzle the children at first, but someone will begin to suspect the reason if the teacher is clever in her questioning. "Why does the compass point north?" will start discussion.

As children handle a compass, or bend over one that is lying on a table, they may notice that the needle moves. This may be caused by a skate key on a string, a child's necklace, a steel belt buckle, or other steel on their clothing.

Since the north magnetic pole of the earth isn't at the north axial pole, the compass needle will deviate except for places on the meridian running through the magnetic pole. East of that meridian, the compass will point northwest. West of it, the needle will point northeast. This will arouse discussion, and a map or globe may be consulted to locate the magnetic pole.

Also questions may be asked as to what would happen to the compass right over the pole. By holding a compass directly above

the pole of a bar magnet, the children will see that the needle spins around.

Be careful that children don't get the idea that the earth has a big bar magnet through it. If the teacher has a piece of lodestone, it will help to clarify the concept that even an uneven chunk of magnetized iron has poles. The easiest way to demonstrate this is to dip the lodestone in iron filings. Then hold first the N, then the S pole of a bar magnet near the filings. Opposite poles will cause the filings to make a bridge between the poles; like poles will push the filings.

To show that magnets attract through various materials, try many, such as wood, glass, and paper. Tin pans and cans are merely coated with tin, and it is the iron underneath which is attracted to the magnet.

Children should be taught to put magnets away with opposite poles together, or with a piece of steel across the ends of U-magnets. Otherwise, the magnetism will be lost. If magnets are kept in a hot place, they will also lose their magnetism.

When children are making a compass by rubbing a needle on the magnet, they will need to know that it must be stroked in the same direction on the same pole.

The experiments with magnets are excellent for teaching methods of problem solving and also for developing the scientific attitude of basing conclusions on sufficient evidence. The understandings gained have many practical applications to everyday life.

If bar magnets are not available, the same experiments may be performed with magnetized steel knitting needles or other bars of steel. To magnetize them, wrap with a number of turns of insulated copper wire and attach to the terminals of a strong dry cell. A few minutes will magnetize a needle sufficiently to do the experiments.

Strong U-magnets may sometimes be obtained from old car magnetos.

Sub-problem. How Does Electricity Work? (Pages 315–327)

*Science Concepts*:

1. Lightning is a big spark of electricity.
2. Electricity may be produced by rubbing things together.

3. The kind of electricity we use is generated in a power plant and flows over wires.
4. Electricity may be produced in dry cells.
5. A dry cell has two terminals. If a wire leads from each one to two terminals on a bell, the bell will ring.
6. An electric current has to flow over a circuit.
7. We use a switch to complete or break a circuit. There are many types of switches.
8. Electric wires must be insulated to prevent electricity from flowing where it isn't wanted.
9. If bare wires touch, they cause a short circuit.
10. Bare wires are dangerous. They may cause fires or shocks.
11. Electricity produces heat when it flows through wires that are poor conductors.
12. Fuses are used to protect our houses. A fuse has a soft metal in it that melts when there is a short circuit and breaks the circuit.

HOW ELECTRICITY WORKS (Pages 315–324)

This story deals with those experiences with electricity that most children wonder about. In presenting it, the teacher should stress safety.

Many children are afraid of lightning and thunder. If they can be made to realize that lightning is just a big electric spark, similar to the small ones they see when a cat's back is rubbed, it may help to destroy that unreasoning fear. Of course lightning does sometimes strike people and buildings. Thunder is the harmless noise that follows a discharge of electricity in the air. Air resists the flow of electricity. The heating of the air by this resistance causes a sudden expansion, similar to any explosion. When the noise is heard, the danger is past. If children are taught the causes of both, they are better equipped to avoid being struck, and are much more calm during a storm.

Lightning is caused by negative charges of electricity, or electrons, jumping through the air to meet positive charges. Fourth-grade children can't understand the technical explanation, but if they are allowed to do the experiments suggested in the story, they will get some idea of this common phenomenon.

As water from the earth evaporates and is pushed up in the air currents, electrons are rubbed off the tiny drops. Thus the clouds may be charged differently. A negative cloud near a positive cloud has a tendency to lose its extra electrons to the positive cloud. This inequality of electrical charges produces electrical pressure or potential. When this potential becomes great enough, there is a discharge which we call lightning.

Often the top of a cloud is negative and the bottom positive. As it nears the earth, electrons are attracted from the earth by the lower part of the cloud. Then the lightning flashes are between the cloud and the earth.

The reason it is dangerous to stand under a tree is that objects going above the earth's surface carry electrons higher and are more apt to be struck than flat country. Lightning rods, being made of metal, carry enough electrons to neutralize the air around them and quietly discharge the electricity. Pipes in buildings do the same thing. Thus buildings are rarely struck. Dry wood is a non-conductor but trees contain sap. Water is an excellent conductor. Thus part of the tree resists the flow and part conducts it to the ground. The part that resists is charred or burned by being heated just as the resistant wires in a toaster are heated. A live animal is a good conductor, so if you are standing under a tree part of the bolt may jump to your body. A human being may conduct a large voltage of electricity to the ground but a bolt of lightning of 6,000 or more volts is nearly sixty times as much as is carried by the light wires into your house. Also, shoes are usually non-conductors and the bolt meeting them creates great heat. Stories often appear in newspapers of people being struck by lightning and having their shoes blown off. The sudden heat and resulting expansion of the air would explain this.

Children should be taught to go inside a building in an electrical storm, not to stand by open doors or windows, or in front of a fireplace. The average building is protected by water pipes and grounded wire but a chimney is sometimes struck and falling bricks might hurt one. If one can't get to a building during a severe storm, choose a low shelter, such as bushes or a grove of trees, or lie flat on the ground. In regions where accidents of this sort are rare, stress on safety measures may not be important, but

fears are based on ignorance, and a knowledge of what to do in case of danger removes fear.

In case a playmate touches a live wire, a fourth-grade child should summon help immediately. The wire may be pushed away or lifted with a *dry* stick of wood such as a broomstick. Be careful not to flip the broken end (uninsulated part) against yourself or any other person. Everyone but the rescuer should stand far back. The person touching the wire may be pulled away from it with a dry rope, rubber hose, cotton scarf, or other non-conducting material. But to touch him with your bare hands means carrying the charge through you. Speed and a knowledge of first aid may save his life. He should be treated for shock.

*Suggested Activities*:

Many simple experiments with static electricity should be done to establish correct concepts. The teacher should not attempt to teach the technical details about positive and negative charges unless the children ask for it.

A simple demonstration is to support a piece of glass on two books. Sprinkle some bits of cork or tissue paper on the table under the glass. Rub the glass briskly with a piece of silk or wool. The bits will jump around and fly up to the glass.

Of course we do not make electricity, we merely generate it. Knowing that static in the air affects the radio helps to clarify this point with children.

The children may use dry cells to run small motors and other electrical toys. They will learn how to connect them in this way. Erectar sets often have suggestions for using electricity, and boys especially are interested. Dry cells generate electricity through chemical change. If the children are interested in what happens, they may tear an old dry cell apart. They will find the carbon center post and zinc cylinder just under the cardboard cover. Between the two is a paste of sal ammoniac that reacts with the carbon and zinc to start a flow of electrons.

With a lemon, a copper-and-zinc plate, and copper wires, a simple wet cell can be constructed. Only a slight current is produced, but one can taste it by putting the ends of the wires in one's mouth. It will taste sour.

A car battery is a series of wet cells. If an old battery can be obtained, it will help in explaining them.

The generating of current electricity is too complicated to explain to fourth-grade children. If there is a power plant near by which they can visit, they can get a general idea.

The children should look at various types of switches and fuses. They can examine the fuse box at school and see what happens to a light circuit if a fuse is removed or blows out. They should learn why it is dangerous to replace a broken fuse with anything else, such as a penny. The penny will carry more volts than the wires will support. They should discuss the danger of broken live wires and safety measures to use in case one is touched or seen.

Before teaching this material the teacher should be sure she has enough background to help the children gain correct concepts.

### STORMS (Pages 325–327)

Since precipitation is closely connected with lightning and thunder, it is discussed here.

The concepts discussed in this chapter have been started in the primary books, but if the children haven't performed experiments with evaporation and condensation, they should do so. See the primary manuals for suggested activities.

If it hails any time during school hours, gather some hailstones and cut them in two. Observe the layers. Ice cubes made in an electric refrigerator often show layers. The difference in their formation and that of hailstones is that the cubes freeze from the outside in, while hail starts with a frozen pellet and adds layers.

When a raindrop freezes, the crystals are too tiny to be seen with the naked eye. It looks like a drop of ice and is called sleet. When water vapor in the air (the invisible gaseous form of water) freezes, the tiny crystals form larger crystals that make the pattern we call a snowflake, or frost (if it forms on objects near the earth). In a mechanical refrigerator, frost forms on the outside of the freezing unit from water vapor in the box.

By putting ice or snow with salt into an aluminum cup or pan, frost may be observed forming on the outside of the container. If the surrounding air is too dry, try breathing on the outside of the container to supply more moisture.

## PROBLEM XX. HOW CAN WE HAVE A GOOD GARDEN?
(Pages 328–337)

*Science Concepts*:

1. Some seeds should be planted early in boxes, and transplanted later to the garden.
2. Most seeds should be planted to a depth of about four times their diameters.
3. After planting, seeds should be sprinkled and put in a warm place.
4. In transplanting, the roots should be disturbed as little as possible.
5. When put into the new soil, the little plants should have their roots moist and surrounded by soil.
6. Garden soil should be carefully prepared and the rows made straight.
7. Cultivating a garden prevents evaporation of water and kills weeds.
8. Plants have many insect enemies that gardeners have to fight.
9. The reward of patient work in a garden is worth the effort.

This story is intended to give children simple instructions for raising vegetables. They apply just as well to a flower garden. Many kinds of flowers, such as pansies and petunias, should be planted in boxes and started in the house or a hotbed.

In cities where no space is available for a school garden, the children may transplant their plants to pots or window boxes. So much pleasure is derived from growing plants that the teacher should make an effort to give her children the experience.

*Suggested Activities*:

The boxes or flats used in this story are easily made of orange crates. The soil should be sifted into the boxes and leveled off with a stick. If no good garden loam is available, a little humus or well-rotted manure should be added to sandy soil. Loam has clay, sand, and humus in it.

Follow the directions on the packages for planting. If the plants

are to be transplanted to other boxes before the final transplanting to the garden, it should be done when they are about 1½ to 2 inches high. Each plant may be taken up with one of the flat, pointed sticks which are sold for marking plants in the garden. If soil can be kept around the roots, all the better. The secret of transplanting is not to allow the tiny roots to dry. Make the hole with a similar stick. A little water should be put into the hole before putting the little plant in. The picture on page 332 shows how to put a stick down parallel to the hole and to push the soil up against the entire root. This should be repeated on the other side of the plant so the entire root touches the soil. Otherwise, the root will dry and the plant will wilt.

Transplanting should be done in the shade or in the evening so as to minimize loss of water. If the sun is hot the following day, the plants may be covered with paper cups. These should be removed toward the end of the day. By the next day, the plants will have recovered from the shock of being moved.

As important as planting is cultivating. It is better for children to plant fewer plants and care for them than to have a large garden of weeds.

The satisfaction that children get from a successful crop will make their interest grow. In many situations, the school plot will be very small and should make children want one at home.

In cities, children may enjoy growing seeds in sand watered with a nutrient solution. *Science Illustrated*, August 1947, gives a simple basic plant formula and directions easily followed in any schoolroom.

## PROBLEM XXI. HOW ARE ANIMALS CLASSIFIED?
(Pages 338–345)

These pages are a summary of some of the concepts taught in THE HOW AND WHY CLUB and previous books of the series. They should be used as reference material to do exercises like the ones given on pages 119–126 of the Companion Book for THE HOW AND WHY CLUB.

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## ADDITIONAL MATERIALS

### Pamphlets, Posters, and Exhibits

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Apparatus and Equipment. General Biological Supply House, Chicago. (Free leaflets.) Welch Manufacturing Company, 1515 Sedgwick Street, Chicago. (An electrically lighted pocket planetarium.)

Audubon Bird Cards. National Association of Audubon Societies.

*Audubon Magazine.* 1000 Fifth Avenue, New York 28, N. Y.

Carnegie Museum Pamphlets. Carnegie Museum, Pittsburgh.

The Amoeba. Fossils.

Camels. Oysters.

Poisonous Plants of Pennsylvania.

Poisonous Snakes of Pennsylvania.

Shells and Civilization.

Other pamphlets available.

General Motors Research Booklets. Department of Public Relations, General Motors Corporation. *A Power Primer,* and others.

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Montana State College, Agricultural Experiment Station. *The Rocky Mountain Wood Tick.* Bulletin 268. (November, 1932)

Pictures and Maps, Pictorial Geography. National Geographic Society, Washington, D. C. United States Geological Survey, Department of the Interior, Washington, D. C. Wild Flower Preservation Society, Washington, D. C.

*School Nature League Bulletin.* 1000 Fifth Avenue, New York 28, N. Y.

Science Kit. 204 Dexter Street, Tonawanda, N. Y. A portable science laboratory containing 70 pieces of apparatus and equipment for grade science.

U. S. Biological Survey. U. S. Government Printing Office, Washington, D. C.

Beaver Culture. How Beavers Build Their Houses.

Bird Migration. Manual for Bird Banders.

U. S. Department of Agriculture, Washington, D. C. Farmer's Bulletins.

Food Habits of Common Hawks.

The Muskrat as a Fur-bearer.

Many other useful bulletins.

U. S. Department of Agriculture, Washington, D. C. Forest Service.

Forest Trees and Forest Regions.

Plant Trees.

Taming Our Forests.

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Water and Our Forests.

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Encyclopedia Britannica Films, Inc., 20 North Wacker Drive, Chicago, Ill.

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Films, Inc., 330 West 42nd Street, New York, N. Y.

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The L. W. Singer Company, Inc., Syracuse, N. Y. (Films correlating with The How and Why Science Series.)

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Celli, Rose. *Wild Animals and Their Little Ones.* The Artists and Writers Guild, Inc.
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## Aviation

Jones, Paul. *An Alphabet of Aviation.* McCrae Smith.
Macmillan, Dobias. *The Picture Book of Flying.* Macmillan.

## Electricity

Bendick, Jeanne. *Electronics for Boys and Girls.* McGraw-Hill.
Ilin, M. *Turning Night into Day.* J. B. Lippincott Company.
Keelor, Katherine L. *Working with Electricity.* Macmillan.
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Websters, Hanson Hart. *The World's Messengers.* Houghton Mifflin Company.
Wyler, Rose, and McSpadden, Warren W. *Electricity Comes to Us.* Georges Duplaix.

### Geology

Cormack, Maribelle, and Alexander, William P. *The Museum Comes to Life.* American Book Company.
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Johnson, Gaylord. *Earthquakes and Volcanoes.* Julian Messner.
Robinson, W. W. *Animals in the Sun.* Harper and Brothers.
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Rugg and Krueger. *First Book of the Earth.* Ginn and Company.

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Bock, George E. *What Makes the Wheels Go Round.* The Macmillan Company.
Clarke, Charles R., and Small, Sidney. *The Boy's Book of Physics.* E. P. Dutton and Company.
Coolidge, Anne, and Di Bona, Anthony. *The Story of Steam.* The John C. Winston Company.
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Reck, Franklin M. *Automobiles, From Start to Finish.* Thomas Y. Crowell.
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Schwarzman, Marguerite Engler. *Steel.* Georges Duplaix.
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### Plants

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### Water Life

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Crowder, William. *Dwellers of the Sea and Shore.* Macmillan.
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# A KEY TO THE COMPANION BOOK

p. 1—*What Do the Signals Mean?*

| | |
|---|---|
| (1) turn left (done) | (2) turn right |
| (3) I don't know | (4) stop |

p. 2—*On Which Side of the Road Should You Ride?*

In both pictures, boy should be riding next to curb on right-hand side of road.

*What Safety Devices Can Be Used on Bicycles?*

| | |
|---|---|
| Safety Devices: | 1, 3, 4, 5, 6, 7 |
| Used during Day: | 3, 5, 6 |
| Used at Night: | 1, 3, 4, 5, 6, 7 |

p. 4—*Things Used at an Airport*

| | | |
|---|---|---|
| 1. airplane (done) | 4. runway | 7. radio antennae |
| 2. engine | 5. hangar | 8. towerman |
| 3. pilot | 6. wind sock | 9. light gun |

p. 5—*How Things Are Used at an Airport*

| | |
|---|---|
| towerman | —controls air traffic |
| radio antennae | —sends messages |
| airplane | —carries passengers |
| pilot | —flies the plane |
| light gun | —gives signals |
| runway | —is a place to land |
| wind sock | —shows direction of the wind |
| engine | —moves the airplane |
| hangar | —protects the airplane |

*Do Airplanes and Bicycles Have Any Parts Which Are the Same?*

| | | | | |
|---|---|---|---|---|
| B A 1. | B A 5. | B 9. | B A 13. | A 17. |
| A 2. | B A 6. | A 10. | B 14. | B 18. |
| B A 3. | A 7. | A 11. | A 15. | |
| A 4. | A 8. | A 12. | A 16. | |

p. 6—*The Parts When Separated*

Counter-clockwise from upper left: propeller, fuselage, engine, wing, wheels, landing gear, rudder, elevator, ailerons.

p. 7—*The Parts When Put Together*

Clockwise from lower left: wheels, landing gear, propeller, engine, wing, fuselage, aileron, rudder, elevator.

*The Parts That Work Closely Together*

1. landing gear—wheels
   propeller—engine
   fuselage—wings
2. rudder—tail
   ailerons—stick
   elevator—tail

p. 8—*Scientists Wonder and Ask Questions*

Put an X before 1, 4, 5, 7.

p. 9—*Questions and Problems*

Put a P before 1, 4, 5, 6, 7, 10.

*How to Get Information to Answer a Problem*

1. experiments
2. explores
3. carefully
4. proves
5. patient
6. conclusions
7. proof
8. reason

p. 10—*Word Meanings*

1. Check sentence *b*.
2. Underline "a person who studies and experiments to find out things."
3. Underline "flap-like things on the edge of the wings."

p. 11—*The Vegetable Cellar*

Picture obvious.

Leaves: Cross out white potatoes, sweet potatoes, beets
Roots: Cross out lettuce, corn, onions, white potatoes
Seeds: Cross out celery, lettuce, turnips

p. 12—*What Part of the Plant Do You Eat?*

The names of the plants as they appear on the page:

1st row: turnip (root) potatoes (stems) radish (root) cabbage (leaves)
2nd row: beet (root) carrot (root) parsnip (root) peanuts (seeds)
3rd row: bean (seed)
4th row: onion (bulb) corn (seeds) spinach (leaves) lettuce (leaves) celery (leafstalk)

p. 13—*What Is in Your Garden?*

tree—starch, sugar
peanut—fat
beet—sugar
carrot—starch
turnip—starch
sweet potato—sugar, starch
Irish potato—starch

p. 14—*What Is in Your Store?*

Vegetables might be Irish potatoes, carrots, turnips.
Refrigerator—butter, cream, cheese.
Meat counter—bacon, fat beef, ham, pork.
Shelves—olives, peanut butter, shortening, cooking oil.

Blanks: leaves, roots, stems, seeds.

p. 15—*What Was the Problem?*

Underline 2.

Underline 2, 4, 6, 8.

*What Were the Experiments?*

1. fat 2. starch 3. sugar

Underline 1, 2, 4, 5.

p. 16—*What Were the Experiments?* (continued)

Underline: I. plants

A. fat B. starch C. sugar

*What Did the Children Find Out?*

I. sugar, starch, fat

A. peanuts
B. Irish potatoes (or any others that are correct)
C. sweet potatoes

Blanks: problems, big, answer (or solve), experiments, big, patience and care (or information and thought).

p. 17—*A Chart About Foods*

Column 1: Cross out butter and salt. (done)
Column 2: Cross out celery, salt, and elm tree twig.
Column 3: Cross out salt and butter.

*What Do You Eat?*

1. bread—starch
2. butter—fat
3. sweet potatoes—starch, sugar
4. ice cream—fat, sugar
5. mashed Irish potatoes—starch
6. peanuts—fat
7. candy—sugar

p. 18—*Testing Foods*

| | | | |
|---|---|---|---|
| Pictures: | 1. fat | 2. sugar | 3. starch |
| Blanks: | 1. greasy | 2. blue | 3. sweet |

p. 19—*A Summary of Chemical Changes*

Column 3: changed color (done)
changed color
changed color
fizzed, bubbled
changed color
fizzed, bubbled

Underline 2.

Number of causes: 3 (if child realizes that lemon juice is an acid); 4 (if he doesn't).

Blank: cause

Underline 2.

p. 20—*Testing for Chemical Changes*

1. acid (done)
2. sugar (and acid in fruits)
3. starch
4. fat

*Acids and Litmus Paper*

Acid: orange, tomato, vinegar, grapefruit
No acid: soda, starch, sugar, flour
Litmus paper changed: orange, tomato, vinegar, grapefruit

*Chemical and Physical Changes*

1. physical change
2. physical change
3. chemical change
4. physical change
5. physical change
6. physical change
7. physical change
8. chemical change

p. 21—*Characteristics of the Beaver*

Compare with complete picture on page 58 of text.

p. 22—*What Other Tails and Feet Do I Know?*

| Tails: | Feet: |
| --- | --- |
| 1. crayfish | 1. monkey |
| 2. squirrel | 2. elephant |
| 3. fish | 3. squirrel |
| 4. cow | 4. beaver |
| 5. beaver | 5. dog |
| 6. elephant | 6. horse |
| 7. kangaroo | 7. cat |
| 8. raccoon | 8. raccoon |
| 9. horse | 9. kangaroo |
| 10. dog | 10. bear |
| 11. cat | 11. cow |

p. 23—*How Beavers Live*

Check with text.

p. 24—*The Homes of Rodents*

(1) Chipmunk
(2) Squirrel
(3) Rat
(4) Rabbit

p. 25—*All Rodents Are Alike in Some Ways*

Underline 1, 4, 5.

*Questions About Rodents*

Place an X before 1, 2, 3, 4, 6, 7.

*How Many Rodents Do You Know?*

1st row: porcupine, mouse, rat, pocket gopher.
2nd row: rabbit, chipmunk, flying squirrel, muskrat.
Blanks: incisor . . . . gnaw.

p. 26—*The Food of Rodents*

1, 2, 3 (done)
4. roots
5. buds or fruit
6. a potato
7. cheese
8. bark or leaves

*Do You Know the Names of Rodents?*

Rodents: chipmunk, muskrat

p. 27—*The Skulls of Rodents*

1st row: top, bottom; front, back; bottom, top
2nd row: bottom, top; top, bottom; back, front

*Rodents and Eating*

Cross out: 1. nails, knife
2. back, side
3. leaves
4. bite, tear

Cross out: *Rabbit*—nuts
*Squirrel*—cabbage, carrots, turnips
*Beaver*—nuts, cabbage, carrots, turnips

p. 28—*Different Kinds of Teeth*

1. canine
2. gnaw

Blanks 1–4: 8 incisors, 4 canines, 8 molars, 8 bicuspids

p. 29—*A Record of My Teeth*

Individual.

p. 30—*Word Meanings*

Underline:

1. Animals that gnaw the food stored in plants (The sentences before *help* also.)
2. tearing
3. grinding teeth
4. (1) small grinders (2) four extra molars
5. paper that has a chemical called litmus in it
6. sour chemicals

p. 31—*Spiders and Silkworms*

True: 1, 4, 6, 10
False: 2, 3, 5, 7, 8, 9, 11

Cross out: 1. the same 2. the same 3. different 4. the same 5. the same

p. 32—*The Life History of Spiders and Insects*

1. yes
2. no
3. no
4. yes (if they understand that by *same* is meant that they are adults)

p. 33—*How Plants and Animals Depend on Each Other*

cactus, desert, armadillo (done)
potatoes, farm, cow
evergreen, mountains, cony
windowbox, city (or farm), cat
seaweed, ocean, fish
water lily, pond, water strider

p. 34—*You Depend on Plants and Animals, Too*

Chart: Individual answers.

*The Animals That Would Disappear*
*The Plants That Would Disappear*

Individual answers.

Put an X in front of 2 and 3 in each list.

p. 35—*A Field Trip to Observe Plants and Animals*

Words as they occur in blanks: fleas, cat, tree, trees, fish, insect, bush, mosquito, mosquitoes, mosquitoes, earthworm, sand burrs, sand burrs.

Underline all 9 words.

p. 36—*A Field Trip* (continued)

flea—dog (done)
cat—tree
fish—water
robin—earthworm
insects—bush
river—rain
mosquito—water (or river)
burrs—boy

pp. 37–39—*A Bone Puzzle*

Obvious.

pp. 40–42—*A Muscle Puzzle*

Obvious.

pp. 43—*Joints*

| Column 1: | Column 2: | Column 3: |
|---|---|---|
| Picture 1 | Picture 3 | Picture 4 |
| Picture 2 (done) | Picture 1 (done) | Picture 2 (done) |
| Picture 3 | Picture 4 | Picture 1 |
| Picture 4 | Picture 2 | Picture 3 |

p. 44—*Bones and Skeletons*

Frog—legs (done)
Dog—legs
Bird—wings and legs
Man—arms and legs
Dinosaur—legs

p. 45—*Your Feet*

Individual answers.

p. 46—*Record of My Height and Weight*

Individual answers.

p. 47—*Food for Your Body*

| | | | |
|---|---|---|---|
| Draw lines through: | cornstarch | peas | corn kernels |
| | cracker | flour | wheat cereal |
| | wheat kernels | bread | |
| | oatmeal | Irish potato | |

| | | |
|---|---|---|
| 1. starch | 5. fat | 9. fat, protein |
| 2. starch | 6. fat | 10. protein |
| 3. starch | 7. fat | 11. protein, mineral |
| 4. starch (or sugar) | 8. protein | 12. mineral |

1. Any three: bread, corn, Irish potato, crackers.
2. sweet potato, peach, banana.
3. butter, peanuts, cheese.
4. Any five: dried beans, eggs, lean meat, milk, fish (or cheese).
5. Any three: bread, cabbage, lettuce (also celery, liver, milk, eggs).

6–10. Individual answers.

p. 48—*Food in Your Body*

1. mouth—saliva changes starch to sugar, chews food
2. stomach—churns food, juices change food more
3. large intestine—waste is eliminated
4. small intestine—juices soften food, digested food goes into blood

p. 49—*How Did the Elephant Get its Trunk?*

Blanks: 1, teeth; 2, nose; 3, 45,000,000.

p. 50—*How Has North America Changed?*

Alaska, Canada, United States, Mexico, Cuba, Central America.

p. 51—*From Soil to Milk*

| | |
|---|---|
| 1st, 2 | 4th, 5 |
| 2nd, 3 | 5th, 1 |
| 3rd, 4 | |

*Pasteurized Foods*

Place an X in front of 2.

Underline cream cheese, ice cream, cream, cottage cheese, butter.

p. 52—*The Milkhouse*

Picture 1: Put X's on closed window, screen door, cooling tank, separator.

Picture 2: Place an X by clean floor.

Blanks:
1. closed screen doors and windows
2. cooling tank
3. clean separator
4. clean floor

Place an X in front of 3 and 5.

p. 53—*Milk and Cleanliness*

Picture 1: Put X's on clean cow, and on clean hands and clean clothes of milker.

Picture 2: Put X's on clean pail; clean walls, floor and stanchion; closed window.

Blanks: 1. clean, unbroken window.
2. clean floors, walls, and stanchion.
3. clean pail, hands, clothing, cow.
4. absence of flies (also, easily cleaned stanchion, walls, and floor).

p. 54—*How Does a Scientist Work?*

Blank: bacteria

Blanks in boxes:

| | |
|---|---|
| flask, neck | spoil |
| flask, broth, bacteria | flask |
| boiled | dust |
| heated | spoiled |
| cooled, broke | bacteria, air |
| air, broth | |

p. 55—*How Does a Scientist Work?* (continued)

Blanks in boxes: necks
broth
cellars, dust
roads, school yards
mountains, dust
dust

1. believed, disease
2. instruments
3. instruments, bandages
4. hydrophobia, dogs
5. milk

1. problem
2. solution
3. decisions
4. experiment
5. compares
6. results

p. 56—*Trailing Animals in Winter*

The first tracks indicate that a rabbit was going to the right.

In the last picture, marks were made by icicles, a branch, and tires.

p. 57—*Trailing Animals in Winter* (continued)

1. skunk
2. rat
3. weasel
4. prairie dog
5. owl
6. cat
7. dog

Picture at bottom: The tracks in the picture tell us that a person walked to the barn.
Individual drawings.

p. 58—*Why Are These Pictures Wrong?*

| | | | |
|---|---|---|---|
| 1. fall | 2. fall | 3. fall | 4. fall |
| 1. table | 2. legs | 3. bowl | 4. water . . . support |

p. 59—*What Does Gravity Affect?*

1. Circle all the words in the list.
2. Check brick, ceiling, floor, wall, bookcase.
3. Arrows should point downward.
4. A curved line to represent the earth should be drawn below picture.

p. 60—*Around the World with Gravity*

Children may draw stick men if pictures on page 60 are too difficult to copy.

The figures should be vertical to the earth's surface. The lines would be drawn from each figure to the center of the earth.

p. 61—*The Sun, the Moon, and the Earth*

| | | |
|---|---|---|
| 1. sun | 2. moon | 3. earth |

Drawings: sun, earth, moon

| | | |
|---|---|---|
| 1. larger | 3. smaller | 5. smaller |
| 2. smaller | 4. larger | 6. larger |

Blank at bottom: sizes

p. 62—*The Earth and the Sun*

1. far away; near him
2. far away; near him
3. far away; far away

p. 63—*More about the Sun, the Moon, and the Earth*

| | | |
|---|---|---|
| 1. farther from | 2. nearer to | 3. no |

Blank: different

Objects: sun—yellow
earth—blue
moon—blue

| | |
|---|---|
| 1. light, reflected, reflected | 4. sun |
| 2. sunlight | 5. reflected |
| 3. sunlight | 6. moon |

p. 64—*More about the Sun, the Moon, and the Earth* (continued)

| | | |
|---|---|---|
| 1. moonlight | 6. sun | 11. sun |
| 2. moonlight | 7. earth | 12. earth (or moon) |
| 3. sunlight | 8. earth | 13. moon (or earth) |
| 4. moon | 9. sun | 14. smaller |
| 5. reflected (or sun) | 10. closer | 15. earth (or sun) |

Circle sentences 1 and 5.

Not true: 2, 3, 4, 6 True: 1 and 5

p. 65—*Some Experiments*

| | |
|---|---|
| 1. flashlight, lamp | 3. baseball |
| 2. walnut | 4. marble |

Moon between earth and sun: 1, 6, 2
Earth between moon and sun: 4, 3, 5
Eclipse of sun: 1, 7, 8

p. 66—*Revolutions of the Earth and the Moon*

Check with page 218 of text.

p. 67—*Making a Record of the Solution of a Problem*

Step I Underline sentences 1, 2, 4, 5.
Put an X in front of sentences 1 and 5.

Step II Check 1, 2, 4, 5, 6.

p. 68—*Making a Record of the Solution of a Problem* (continued)

Step III Underline 1, 2, 4, 7.
Underline 1, 2, 3, 4, 8.

Step IV Check 1, 2, 3, 4.

p. 69—*Making a Record of the Solution of a Problem* (continued)

Step IV Check sentence 7.
Blanks: chewed, sugar

Step V Underline 1, 2, 3, 5.
Question: no

Step VI There is moisture in the potato, and in a warm, dark place the starch changes to sugar. This makes the buds start to grow. (To the Teacher: any answer which contains these main ideas is correct.)
Numbers: 1, 2, 4, 5.

p. 70—*Why Some Things Move on the Surface of the Earth*

1. Circle the pictures of the boy and the wheelbarrow.
2. Circle the words *wheelbarrow* and *boy*.

Underline sentence 2.

1. boy  2. pushed  3. wheelbarrow  4. moved

p. 71—*Why Some Things Move on the Surface of the Earth* (continued)

1. Circle the picture of the stones.
2. Circle the word *stones*.

Underline sentence 1.

1. river  2. pushed  3. stones  4. moved

p. 72—*Why Some Things Move on the Surface of the Earth* (continued)

1, 2, 3. Arrows obvious.

1. pushed, moved  2. pushed, stones  3. Glacier, moved

p. 73—*Summarizing Why Some Things Move on the Earth's Surface*

Underline sentence 2.

1. move  2. move  3. move

Blanks: moving, forced, move

Circle: 1. pushed  2. pushed  3. pushed  4. pushed  5. forced  6. carried

Blanks: pushed, forced, carried

p. 74—*Summarizing Why Some Things Move on the Earth's Surface* (continued)

1. force
2. force
3. moves
4. moves
5. changed

Underline on page 73: 1. out  2. up  3. out  4. ahead  5. through  6. away

Blank: many

1. freezing water
2. all directions
3. freezing water
4. all directions

p. 75—*How Gravity Moves Objects*

Picture: Boy pulling wheelbarrow around which he has thrown the rope.

1. 1  2. pulled, gravity

p. 76—*How Gravity Moves Objects* (continued)

| | | |
|---|---|---|
| 1. pushed, pulled | 4. pushed, earth | 7. pulled |
| 2. pushed, pulled | 5. push, pull | |
| 3. pushed, pulled | 6. time | |

Circle 1, 2, 3, 4, 5, 6.

Blank: Forces move things on the earth.

p. 77—*Learning How to Compare Things*

True: Sentences 2 and 4.

| | | | |
|---|---|---|---|
| Circle: | 1. bigger | 3. bigger | 5. same |
| | 2. bigger | 4. taller | 6. smaller |

1. taller, shorter, smaller, larger, same
2. more, fewer, same
3. before, after, same

p. 78—*Learning How to Compare Things* (continued)

| | | | |
|---|---|---|---|
| Blanks: | 1. before | 5. more | 9. after |
| | 2. after | 6. smaller | 10. smaller |
| | 3. after | 7. smaller | |
| | 4. smaller | 8. no | |

Effect: 2, 4, 5, 6

Cause and effect: 3, 9

1. When the glacier moves across it.
2. The land changes.
3. The glacier caused the changes.
4. The glacier changed the land.

p. 79—*Cause and Effect*

| | | | |
|---|---|---|---|
| Cause 1. | Cause 6. | Effect 11. | Cause 16. |
| Cause 2. | Cause 7. | Effect 12. | Effect 17. |
| Cause 3. | Cause 8. | Effect 13. | Cause 18. |
| Cause 4. | Cause 9. | Effect 14. | Cause 19. |
| Cause 5. | Effect 10. | Effect 15. | . . . . 20. |

*Do You Know the Things That Are Part of the Weather?*

1. Weather: 7, 8, 10, 13, 14, 16, 17
2. Underline: 6, 9, 12, 15, 20
3. Write an S before 3 and 5.
4. Circle: 1, 4, 7, 8, 9, 11, 12, 13, 14, 15, 17, 18, 19, 20
5. Put an X before 7, 8, 9, 12, 13, 14, 15, 17, 20.

p. 80—*Does All Snow Contain the Same Amount of Water?*

Answers for 1, 2, 3, and 4 will depend on snowfall.

5. Not all snow contains the same amount of water.

p. 81—*Does All Ice Contain the Same Amount of Water?*

Answers for 1, 2, 3, and 4 will depend on water.

5. Yes
6. Correct: Different kinds of water make the same amounts of ice.

*Which Has More Water in It, Snow or Ice?*

1. line through 1
2. no
3. line through 3
4. yes

p. 82—*Safety at Home and in the Workshop*

Obvious.

p. 83—*How Does Light Hurt Our Eyes?*

1. putting on his hat; to protect his eyes
2. turning his head; to protect his eyes
3. squinting; to protect his eyes
4. putting on colored glasses; to protect his eyes
5. shading his eyes; to protect his eyes
6. blinking; to protect his eyes

p. 84—*How Can We Protect Our Eyes from Light Which Hurts Them?*

Circle 4.

Picture 1: Check 1 and 7.
Picture 2: Check 2 and 7.
Picture 3: Check 3 and 7.
Picture 4: Check 5 and 7.
Picture 5: Check 4 and 7.
Picture 6: Check 6 and 7.

Blank: 7

Blank: protecting

Underline 4.

p. 85—*How Can We Protect Our Eyes from Light Which Hurts Them?* (continued)

Picture 1: Check 1 and 7.
Picture 2: Check 2 and 7.
Picture 3: Check 3 and 7.
Picture 4: Check 4 and 7.
Picture 5: Check 5 and 7.
Picture 6: Check 6 and 7.

Blank: 7

Blank: hurting

Blanks: protecting, eyes, light, hurts

1. *a.* 2. *a.* 3. *a.* 4. *a.*

Blanks: 1, 2, 3, 4; blink, squint

p. 86—*Ways in Which We Protect Our Eyes*

1. putting on a hat
2. turning his head
3. squinting
4. putting on colored glasses
5. shading his eyes with hands
6. blinking

p. 87—*What Is Glare?*

1. windshield
2. book
3. snow
4. sand
5. reflector

Lines: 1. (done)
2. to windshield and from it
3. to book and from it
4. to snow and from it
5. to sand and from it
6. to reflector and from it

Blank: reflect

p. 88—*What Is Glare?* (continued)

1. (done)
2. arrow to windshield
3. arrow to book
4. arrow to snow
5. arrow to sand
6. arrow to reflector

Light hurts our eyes when a great deal of it is reflected from a smooth surface and causes a glare. (Any main ideas similar to these should be counted correct.)

p. 89—*Light and Safety*

| | |
|---|---|
| 1. 7, 9 | 6. 10 |
| 2. 1, 3, 4, 5, 6 | 7. 4 |
| 3. 2, 8, 10 | 8. 1, 2, 5, 6, 7, 8 |
| 4. 1, 7, 8 | 9. 10 |
| 5. 2, 3, 5, 6 | |

1. prevent    2. hearing, touch

p. 90—*Colors of the Spectrum*

| | |
|---|---|
| 1. violet | *a.* violet |
| 2. indigo | *b.* indigo |
| 3. blue | *c.* blue |
| 4. green | *d.* green |
| 5. yellow | *e.* yellow |
| 6. orange | *f.* orange |
| 7. red | *g.* red |

p. 91—*Why Do We See Only Some Colors?*

| | | |
|---|---|---|
| 1. violet | 3. blue | 2. indigo |
| 7. red | 4. green | 4. green |
| | | 6. orange |
| 3. blue | 1. violet | 1. violet |
| | 5. yellow | 2. indigo |
| | 7. red | 6. orange |

p. 92—*Spectrum Colors on a Leaf*

1. white
2. violet, indigo, blue, green, yellow, orange, red
3. violet, indigo, blue, green, yellow, orange, red
4. green
5. absorbed
6. green
7. all colors except green

p. 93—*A Leaf and Light*

1. white
2. green
3. absorbed
4. green
5. all colors except green

p. 94—*Colors Reflected from the American Flag*

1. red, blue
2. violet, indigo, green, yellow, orange
3. blue
4. all colors except blue

| | |
|---|---|
| 1. coat reflects only red<br>2. eyes reflect only blue<br>3. all colors are reflected<br>4. all colors are absorbed | Any ideas which mean same as these are correct. |

p. 95—*Kinds of Buds*

O before Horse-Chestnut, Ohio Buckeye, Silver Maple

p. 96—*Kinds of Buds and Leaves*

O before Rock Maple, White Ash, Norway Maple, Red Ash

p. 97—*Simple Leaves*

S before Rock Maple, Poplar, Black Oak, Aspen, Magnolia, White Beech, American Elm, Silver Maple, Hackberry, Norway Maple, Yellow Birch

p. 98—*Compound Leaves*

C before Shagbark Hickory, Ohio Buckeye, White Ash, Red Ash, Black Walnut, Horse-Chestnut, Honey Locust

p. 99—*The Maple Family*

Column 1 (vertical): no maple leaves
Column 2 (vertical): 1 and 2 are maple leaves.
Column 3 (vertical): 2, 3, and 4 are maple leaves.

p. 100—*The Ash Family*

Column 1 (vertical): 2 and 5 are ash leaves.
Column 2 (vertical): no ash leaves
Column 3 (vertical): 2 and 5 are ash leaves.

p. 101—*The Horse-Chestnut Family*

Individual drawings.

p. 102—*How the Club Solved Some Problems*

See page 106 of this Companion Book.

1. 2, 5, 6, 7, 8, 9, 10
2. 2, 5, 6, 7, 8, 9, 10
3. 5, 7, 8, 10
4. 4, 5, 7, 8, 9, 10

p. 103—*Rules for Studying Out of Doors*

Check sentences 2, 3, 4, 5, 7, 9, 10, 12, 13, 14, 16, 17, 19, 20

p. 104—*One Problem the Club Solved*

What are the habits of woodpeckers?

*The Woodpecker Family*

1. nest-building habits of flicker
2. chips
3. sight, hearing
4. mustache
5. two birds courting

| | |
|---|---|
| male (done) | 1. |
| robin (or any song bird) | 2. |
| tongues | 6. |
| chisel | 7. |
| ants | 10. |

p. 105—*Field Notebooks*

1. seed-
2. cardinal
3. downy
4. tail
5. bill
6. ant
7. chisel
8. toes
9. pointed
10. red-headed
11. black
12. seed-
13. insects

p. 106—*Field Notebooks* (continued)

1. blackbird
2. white
3. yellow
4. black
5. beak
6. stiff
7. pointed
8. two
9. backward
10. tongue

p. 107—*This Is One Way*

Important Things I Can See: children, train, road, track (or any other visible things children might name)
Important Things I Can Not See: sound
1.    2. sound    3. sound, hear

p. 108—*This Is Another Way*

Important Things I Can See: snowsuits, snow, trees, sled (or any other visible things children might name)
Important Things I Can Not See: cold
1. cold    2. cold    3. cold, cold, feel

p. 109—*This Is a Third Way*

Important Things I Can See: magnet, tacks
Important Things I Can Not See: magnetism
1. magnetism    2. magnetism    3. magnetism, see

| | | | |
|---|---|---|---|
| Column 1: | Picture 1, sound | Column 2: | hear |
| | Picture 2, cold | | (done) |
| | Picture 3, magnetism | | We see what happens. |

p. 110—*Other Things We Can Not See*

Important Things I Can see: tree, leaves
Important Things I Can Not See: wind
1. wind    2. wind    3. wind, see
Important Things I Can See: nest, tree, egg, needles
Important Things I Can Not See: gravity
1. gravity    2. gravity    3. gravity, see

p. 111—*Other Things We Can Not See* (continued)

Important Things I Can See: hot plate, pan, water
Important Things I Can Not See: heat
1. heat    2. heat    3. heat, see

*A Summary*

| | | | |
|---|---|---|---|
| Column 1: | Picture 1 (done) | Column 2: | hear |
| | Picture 2, cold | | (done) |
| | Picture 3, magnetism | | see |
| | Picture 4 (done) | | see |
| | Picture 5, gravity | | (done) |
| | Picture 6 (done) | | see what happens |

sound, cold, magnetism, wind, gravity, heat

1. feel  2. hear  3. happens

p. 112—*Things We Can Not See, Hear, or Feel*

1. It has gone out.
2. The oxygen was used.
1. The light is on (*or* light is in it).
2. The objects reflect light.
1. It is lighted.
2. wires connected, electricity flowing
1. He fell down.
2. gravity
1. The tacks are on magnet.
2. magnetism

p. 113—*Things We Can Not See, Hear, or Feel* (continued)

Underline: magnetism, gravity, oxygen was used (2, 4, 9)

| What happened: | | Why did it happen? | |
|---|---|---|---|
| | 1. 1 | | 1. 2 |
| | 2. 3 | | 2. 4 |
| | 3. 5 | | 3. 6 |
| | 4. 7 | | 4. 8 |
| | 5. 10 | | 5. 9 |

Blanks: cause
Effect

p. 114—*Magnets and Gravity*

| | | |
|---|---|---|
| magnetism | gravity | gravity, magnetism |
| magnetism | gravity, magnetism | gravity, magnetism |
| gravity, magnetism | gravity | gravity |

p. 115—*Magnets and Gravity* (continued)

Magnets are pulling: tacks, horseshoe magnet

Gravity is pulling: water, bar magnet, leaves of tree, ball, rain, boy

Blanks: center, center, center, center

Blanks: down
center of the earth

p. 116—*More Causes and Effects*

Check 2, 3, 4, 6, 7, 12, 13, 14, 16.
Circle 4, 8, 9, 10, 11.
Underline: The earth's pull is called gravity.

p. 117—*More Word Meanings*

1. the gas in the air which we use when we breathe
2. the gas which all animals breathe out
3. push each other away
4. two screws on the top of the dry cell
5. have power to draw
6. a big spark of electricity

p. 118—*Planting Seeds*

Individual answers.

p. 119—*A Platypus*

1. *a.* It has webbed feet.
   *b.* It has a bill-like mouth.
   *c.* It lays eggs.
2. *a.* It has fur.
   *b.* It feeds its young on milk.
   *c.* It has no wings.
3. *a.* It has fur.
   *b.* It feeds its young on milk.
   *c.* It has no wings.
4. mammals

p. 120—*A Bat*

1. *a.* It flies.
   *b.* It has wings.
   *c.* It catches insects.
2. feathers
3. mammals
4. milk
5. bat
6. mammals

| | |
|---|---|
| Chart: (done) | hair |
| (done) | milk |
| bill | (done) |
| hatch from eggs | (done) |

p. 121—*A Manati*

1. It eats seaweeds and looks like a cow.
2. mammals
3. *a.* It feeds its young milk.
   *b.* It can not breathe under water.
4. arms
5. fins
6. The young one was getting milk from its mother.
7. It was breathing above water.
8. whale

p. 122—*A Seal*

1. mammals
2. *a.* It feeds its young milk.
   *b.* It has hair on its skin.
   *c.* It breathes through its lungs.
   *d.* It is warm-blooded.
   *e.* Its young are born alive.

*A Penguin*

1. birds
2. Individual answers.

p. 123—*A Barking Frog*

Class: amphibians

1. smooth
2. claws
3. tadpoles
4. turn

| | | |
|---|---|---|
| Chart: | amphibian | (done) |
| | (done) | scales |
| | no claws | (done) |
| | tadpoles | in sand |
| | (done) | has a neck |

p. 124—*A Dragon*

1. reported
2. crawled on the ground

3. *a.* They had claws on their toes.
   *b.* They were covered with scales.
4. They beat the ground with their tails.
5. reptiles
6. lizard

p. 125—*A Flying Fish*

1. fish
2. *a.* It has fins.
   *b.* It has scales.
   *c.* It has gills.
3. seems to fly up from one wave and glide to the next one
4. glide

*A Six-Legged Animal*

insects

p. 126—*A Crab*

with crayfish

*A Scorpion*

1. eight
2. spiders
3. with spiders
4. with spiders

p. 127—*Animals I Have Seen*

Individual answers.

p. 128—*Word Meanings*

1. suspended
2. abdomen
3. spinnerets
4. pollen
5. fertilizer (done)
6. carbon dioxide
7. hinged
8. skeleton
9. digestion
10. saliva
11. microscope
12. raw
13. constellation
14. erosion
15. prism
16. ventilation
17. circuit
18. warm-blooded

Date Due

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